PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION

Engineering Library
MAY 23 1922

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXIII.—No. 2941.] *LONDON: FRIDAY, MAY 12, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd.,
ROCHESTER.
9663
Steam
Road Rollers & Tractors.

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, pages 29 and 69, last week.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2179

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28, 1921.

Locomotive Shunting Cranes
Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY.
637
LIST OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W. 1.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 9674

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9044

"Spencer-Hopwood" Patent Boilers. *See page 80, May 5.*
Sole Makers:
SPENCER-BONECOURT, LTD., 577
Parliament Mansions, Victoria St., London, S.W.

SIROCCO AND STURTEVANT FANS.
We have a Large Stock of all standard sizes, No. 3 to 12 inclusive (15 in. to 60 in. diameter Runners), ex various Government Depts.
Can guarantee condition, new or equal to new, and supply either hand or discharge for any drive.
Enquiries welcomed.
PROGRESSIVE ENGINEERING CO., LTD., Leicester. 9783

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794

Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS. 516
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH.

Brett's Patent Lifter Co.
LIMITED.
Hammers, Presses, Furnaces,
COVENTRY. 610

Bever, Dorling & Co., Ltd.,
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 9048

Telegrams:—"Cylinders," Birmingham.
Weldless-Steel Tubes
for Water-tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. O 8179

Yarrow & Co. (1922), Ltd.,
SHIPBUILDERS AND ENGINEERS, GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 9563
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

Vosper & Co., Ltd.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od3551
ENGINEERS & BOILER MAKERS.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17, May 5. 9947

The Mitchell Conveyor and
TRANSPORTER CO., LTD.,
CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS
of
all Classes of HANDLING MACHINERY.
Atlantic House,
45-50, Holborn Viaduct,
London, E.C. 1.
Telegrams: "Micontrace, Cent, London."
Telephone: Holborn 286. 9789

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 540

Diesel Engines, Six Cylinder,
Two and Four stroke, 850, 1000, 1300 H.P., excellent condition. Dynamos for above 250 or 500 volts, D.C. Immediate delivery and low price.
Two 500 Kw. Parsons Turbine Sets, 250 or 500 volts, D.C., with condensing plant and spare armature. Price £2200.
Electrical driven Centrifugal, Ram and other Pumps from 1½ in.-10 in. outlet.
JENNINGS, 9742
West Walls, Newcastle-on-Tyne.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, GLASGOW. Od 5547
Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W. 1.

Drawing Office.
All classes of mechanical and structural work undertaken. Special plants designed and supervised during erection. Contracts for plant and machinery handled and supervised throughout.
OWEN & CRISP,
64, Basinghall Street, London, E.C.2.
Telephone No.: London Wall 5606. 9650

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8748
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 75.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, } ROW'S PATENTS.
CONDENSERS, AIR HEATERS,
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 8732

Tubes and Fittings,
IRON AND STEEL.
Stewarts and Lloyd's Ltd.,
41, OSWALD ST., GLASGOW.
BROAD STREET CHAMBERS, BIRMINGHAM, and LONDON OFFICE—
WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—167, UPR. THAMES ST., E.C.
LIVERPOOL WAREHOUSE—63, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSE—NILE STREET, SHEEPSCOTE STREET.
See Advertisement, page 26. 9952

Economy!
HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING
Todd Oil Burners
FUEL OIL BURNING SYSTEMS, HEATERS, STRAINERS.
49-51, EASTCHEAP, LONDON, E.C. 3.
TODD SHIPYARDS CORPORATION,
Builders of Steam and Motor Ships, Repairers, Electric Drive Installations.
Twenty-one Floating Docks, Two Graving Docks, Twelve Shipways.
25, Broadway, New York, U.S.A. 9960

Patent
See's Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 30 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C. 3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 9804

A Time Recorder, as New, guaranteed, latest model. WHAT OFFERS? —A. G. PHILLEY, 149, Farringdon Road, E.C. 1. F 599

Electric Cranes.
Traversers.
Transporters.
Lifts.
S. H. HEYWOOD & Co., LTD., Reddish. 9963

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON and BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C. Od 3362

Yarrow Patent
Water-Tube Boilers. 9644
Messrs. YARROW & CO. UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO. (1922), LTD., SCOTSTOUN, GLASGOW.

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3362

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 64, May 5. 2402

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 9618
See Full Page Advt., page 48, April 28.

Taylor & Challen
Presses
8195
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full page Advertisement, page 65, April 28.

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 600

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED.
Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD., LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 16. 9764

WAYGOOD-OTIS LIFTS. 710
54 & 55, FETTER LANE, LONDON, E.C. 4.
62 & 63, LIONEL STREET, BIRMINGHAM.
and Principal Provincial Cities.

A. P. Thurston, D.Sc.
Engineering. Expert advice on Patents, Inventions, Models and Designs.—39, Southampton Buildings, W.C. 2. Holborn, 2543. 9961
'Phone—Holb. 541. Tele—Andrubo, Holb., London.

Andrews & Beaumont,
CHARTERED PATENT AGENTS, 870
39, Southampton Buildings, London, W.C. 2.

S. Sokal, CHARTERED PATENT AGENT.
1, Great James Street, Bedford Row, London, W.C.1.
T.N. 4515 Museum. 9675

See Advt. page 99, May 5
Steam
& Pneumatic Power Hammers
Drop Stamping Plant
B. & S. Massey, Ltd., 9911 MANCHESTER.

The Manchester Steam Users' ASSOCIATION.
For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 598

Civil Service Commission—FORTHCOMING EXAMINATION.—INSPECTORS in the Engineer-in-Chief's Department of the General Post Office (17-22), 8th June.
The date specified is the latest on which applications can be received. They must be made on forms to be obtained, with particulars, from The SECRETARY, Civil Service Commission, Burlington Gardens, London, W. 1. U 184

Correspondence Courses for Inst. Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by MR. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 56, SOUTH JOHN STREET, LIVERPOOL. 576

Inst. C.E., I. Mech. E., B.Sc., and all Engineering Examinations.—Mr. G. F. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4180 Victoria. 566

Inst. C.E. Exams.—Successes as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience. Address, 7434, Offices of ENGINEERING.

Powering of Vessels.—A Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 748, Offices of ENGINEERING.

Penningtons, University TUTORS, 284, Oxford Road, Manchester. Estab. 1876. Enrol now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 9750

TENDERS.

VENTNOR URBAN DISTRICT COUNCIL.

REPAIRS TO TIE RODS, &c., TO THE ROYAL VICTORIA PIER AND LANDING STAGE.

The Ventnor Urban District Council invite

Tenders for the Repair and REPLACEMENT of a number of TIE RODS and OTHER IRONWORK to the understructure of the Royal Victoria Pier and Landing Stage, Ventnor.

Plans, Sections and Specification may be seen at the office of Mr. D. V. HOWARD, the Engineer and Surveyor to the Council, Town Hall, Ventnor, I.W.

Tenders, sealed and endorsed "Pier Repairs," to be delivered to the undersigned not later than noon on the 7th day of June, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

(Signed), JAMES WEARING,
Clerk to the Council.

Town Hall, Ventnor, I.W.,
May 10, 1920. U 186

NOTTINGHAM CORPORATION.

NORTH WILFORD POWER STATION.

The Nottingham Corporation invite

Tenders for the Manufacture, DELIVERY and ERECTION of the undermentioned ENGINEERING WORKS, in connection with the above Station, viz.:—

SECTION "D."—Six Steel Tube Fuel Economisers, Four Steel Chimneys, Six Induced Draught Fans, etc.

SECTION "E."—Extra High-pressure Remote Controlled Main Switchgear, extra High-pressure Hand Operated Auxiliary Switchgear, Low-pressure Hand Operated Auxiliary Switchgear, Cable Connections, etc.

SECTION "F."—Three 30-inch, one 10-inch and three 3-inch Electrically Driven Centrifugal Pumps.

SECTION "J."—One 75-ton Overhead Travelling Electric Crane, One 10-ton Overhead Travelling Hand Crane, One 5-ton Overhead Travelling Hand Crane, etc.

SECTION "K."—Two 750 kilowatt Rotary Converters, One 35 kilowatt Motor-Generator-Booster, etc.

Specifications, General Conditions and Forms of Tender may be obtained from Messrs. PARSON, CARDEW & RIDER, 8, Queen Anne's Gate, Westminster, S.W. 1, on payment of a deposit of £5 for each Section, which will be refunded on receipt of a *bona fide* Tender within the prescribed time.

Extra Copies of the Specifications may be obtained on payment of Ten Shillings for each copy, which will not be returnable.

Sealed Tenders, endorsed "Electricity Department, Tender for....." must be delivered to me at my Office before Ten a.m. on Friday, 9th June, 1922.

The lowest or any Tender will not necessarily be accepted, and the Corporation will not consider any Tender which is incomplete, or which does not include the whole of the work covered by the Specification.

By Order,
W. J. BOARD,
Town Clerk.

Guildhall, Nottingham,
8th May, 1922. U 173

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

No.		Fee for Specification.
1.	Roofwork (for Goods Shed)	£1
2.	Canvases, &c.	10s. 0d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Roofwork," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 23rd May, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
43, Copthall Avenue, London, E.C. 2.
10th May, 1922. U 200

ROYAL BURGH OF KIRKCALDY.

ELECTRICITY WORKS—VICTORIA ROAD.

The Provost, Magistrates and Council invite

Tenders for the following WORK:—

SPECIFICATION No. 1.—STEAM TURBINE, THREE PHASE ALTERNATOR, CONDENSING PLANT and PIPING.

A copy of the Specification and accompanying Drawings can be seen at and obtained from the offices of Messrs. KENNEDY & DONKIN, 17, Victoria Street, Westminster, S.W. 1, on and after Saturday, May 13th, upon payment of a deposit of £2 2s. An additional copy of the Specification can be obtained upon payment of a deposit of £1 1s. These deposits will be returned after the receipt of a *bona fide* Tender, and on the return of the Specification and Drawings.

Tenders on the prescribed Form, enclosed in sealed envelopes, and addressed on the outside—"Electricity Supply. Tender to Specification No. 1,"

must be delivered at the office of the undersigned not later than Ten a.m. on Monday, 5th June.

W. L. MACINDOE, Esq.,
Town Clerk's Office,
Kirkcaldy.

May, 1922. U 187

CORPORATION OF CALCUTTA.

WATERWORKS EXTENSION CONTRACTS, 1921.

PUMPING MACHINERY CONTRACTS.

The Corporation of Calcutta are prepared to receive

Tenders for the following WORKS, which include the Manufacture, Supply, Delivery, Erection, and Setting to work of the following PUMPING INSTALLATIONS:—

CONTRACT No. 10.—Pulta Pressure Station. Three Steam Driven Pumping Engines, each to deliver one and a half million gallons of water per hour against 130 ft. head, Boilers, Stokers, Coal Handling Plant, Electrically Driven Auxiliaries, etc.

CONTRACT No. 11.—Tallah Pressure Station. Three Steam Driven Pumping Engines, etc., etc., same as for Contract No. 10.

Plans can be seen and copies of Specifications, Tenders, etc., and any further information required can be obtained:—

In England:—From the Consulting Engineers, Messrs. ST. GEORGE-MOORE and LA TROBE-BATEMAN, MM.Inst.C.E., 91, Victoria Street, Westminster, S.W. 1, and

In India:—From J. R. COATS, Esq., B.Sc., M.Inst.C.E., Chief Engineer to the Corporation of Calcutta, Central Municipal Office, Calcutta.

For each Contract the sum of £5, or Rs. 75 respectively, will be charged for a set of four copies of the Contract documents, which sum will be returned on receipt of a *bona fide* Tender.

Two copies of all Tenders, from wherever emanating, to be delivered at the offices of the Consulting Engineers in London at or before Twelve noon on the 24th July, 1922, when they will be officially opened in the presence of such tenderers as care to attend. The third copy to be despatched by registered post on or before the same date addressed to the Chief Engineer, Corporation of Calcutta, Central Municipal Office, Calcutta.

Tenders to be in sealed covers and superscribed "Corporation of Calcutta, Tender for Pumping Machinery."

The Corporation do not bind themselves to accept the lowest or any Tender.

Tenderers may submit separate Tenders for alternative proposals.

B. V. RAMIAH,
Secretary to the Corporation.

Central Municipal Office,
18th April, 1922. U 178

APPOINTMENTS OPEN.

DARLINGTON EDUCATION COMMITTEE.

TECHNICAL COLLEGE.

Principal - - J. W. ANGLES, M.Sc.

Assistant Lecturer in Engi- NEERING REQUIRED. Preference will be given to Graduates of British Universities with Works and Teaching experience. Salary in accordance with the Burnham Technical Scale. Forms of Application and particulars may be obtained from, and completed Forms should be returned by the 20th instant to, the CHIEF EDUCATION OFFICER, Darlington. U 167

Wanted, Works Manager, by an up-to-date Non-Ferrous Rolling Mill and Tube Works in the Birmingham District. Preference given to applicant with Engineering Experience. Write in strict confidence, stating age, experience and salary required.—Address, U 143, Offices of ENGINEERING.

GLOUCESTERSHIRE COUNTY COUNCIL.

MAIN ROAD SURVEYOR.

Applications are Invited on or before the 26th May, 1922, for an APPOINTMENT to the POSITION of MAIN ROAD SURVEYOR under the Council.

Applicants must have served overseas in the late War, and be trained Civil Engineers with road experience.

Age not to exceed 36 years.

Basic Salary £180 per annum, plus bonus on sliding scale, at present £131, totalling £311, with £120 per annum allowance for Motor Bicycle and Sidecar.

Forms of applicaton and details of duties may be obtained from—

COUNTY SURVEYOR,
Shire Hall, Gloucester. U 179

A Large Firm in the North of England, who have in hand Extensive Constructional work, including the instalment of machinery, workshops, etc., REQUIRE the SERVICES of a First-class ESTIMATOR. Only those with sound experience in estimating the cost of general constructional work and machinery should apply. State age, salary required and full particulars of experience.—Address, in first instance, U 174, Offices of ENGINEERING.

Traveller for Tubes and Fittings, London district, REQUIRED, with good connection. Only those need apply who are really workers. Permanency and prospects to the right man.—Write in confidence, giving full particulars, stating age, salary required, etc., to ZK 606, c/o DEACON'S, Leadenhall Street, E.C. 3. U 196

Salesman Wanted to Represent Firm manufacturing Gas, Water, Steam and Hydraulic Fittings, including Pipe Lines, Welded Steel Fittings for Oil, Water and Hydraulic. Previous experience in this class of business essential. State age, salary required, giving full details of previous employment.—Address, U 194, Offices of ENGINEERING.

NOTICE.

COLOMBO MUNICIPALITY, CEYLON.

Required by the Municipal Council, Colombo, Ceylon, an ASSISTANT DRAINAGE ENGINEER.

Candidates must have passed the examination of the Associate Members of the Institute of Civil Engineers, and have had a good experience of modern sewerage, sewage disposal, and house connection work. They should not exceed 30 years of age, and preferably be unmarried.

Appointment on probation, three years, on a salary of Rs. 9,000 per annum, with travelling allowance of Rs. 900 per annum. Thereafter, permanent pensionable appointment on incremental basis guaranteed for efficient probationary service, with suitable leave. Free first-class passage to Colombo, and half pay on voyage.

Application forms and full details can be obtained from the Council's London Agents, Messrs. John Fook & Co., 68, Fenchurch Street, London, to whom candidates should apply before May 31st, 1922.

B. H. JOSEPH,
Secretary, Municipal Council,
Colombo.

The Town Hall,
Colombo, March, 1922. U 117

CORPORATION OF CALCUTTA.

APPOINTMENT OF EXECUTIVE ENGINEER, WATER WORKS.

Applications are Invited for the POST of EXECUTIVE ENGINEER, Water Works, Calcutta.

2. The salary of the appointment inclusive of all allowances (except motor car allowance of Rs. 100) is Rs. 1,000 to 1,500 according to qualifications and experience. The post is for a period of five years.

3. The person appointed will be required to keep a motor car, for the upkeep of which the Corporation will pay him an allowance of Rs. 100 per month. The cost of a motor car will, if desired, be advanced by the Corporation and recovered in monthly instalments spread over three years, on the motor car being mortgaged to the Corporation.

4. The appointment is subject to the Provident Fund, leave, and other service rules of the Corporation and may be terminated at any time by six months' notice on either side. The Provident Fund contribution is 8½ per cent. of the monthly salary and an equivalent amount is contributed by the Corporation and the fund accumulates at compound interest.

5. The selected candidate will be required to devote his whole time to the duties of his office and will not be allowed to take up any outside work. He must reside in Calcutta. He will be liable to removal during the term of his office for misconduct or neglect of, or incapacity for his duties. He will be required to submit to a medical examination before joining his appointment.

6. The Corporation will pay his passage (1st class) from London to Calcutta, but he must refund the amount so paid if he gives notice any time within two years from the date of taking up his appointment.

7. He will be required to take up his appointment about the 1st October, 1922, and will receive half-pay for the period occupied by the journey.

8. Preference will be given to candidates who are Members or Associate Members of the Institute of Civil Engineers or Graduates in Engineering of a University, and have had waterworks experience especially in regard to pumping machinery and modern methods of waste prevention.

9. Candidates are to state their age, qualifications and experience.

10. Applications will be received in England up to Monday, the 12th June, 1922, by W. C. RASTON, Esq., B.Sc., M.I.C.E., 149, West George Street, Glasgow, from whom any other information concerning the conditions of service may be obtained; or in Calcutta up to Monday, the 12th June, 1922, by the Chief Engineer to the Corporation of Calcutta.

B. V. RAMIAH,
Secretary to the Corporation.

Central Municipal Office,
Calcutta, 12th April, 1922. U 113

Wanted, by Firm of Crane Manufacturers in Manchester district, First-class DRAUGHTSMAN. State salary and full particulars.—Address, U 175, Offices of ENGINEERING.

Leading Draughtsman Re- QUIRED immediately for large manufacturing firm to check all classes of work. Must be accustomed to depending on own initiative. State full particulars of training, experience, and salary required.—Address, U 165, Offices of ENGINEERING.

Designing Draughtsman REQUIRED in East Anglia, with practical experience in either textile printing or similar plant. Man of broad ideas, capable of developing a range of special machinery.—Write, stating age, experience and salary required to BOX 287, W. S. CRAWFORD, LTD., 23½, High Holborn, London, W.C. 1. U 171

Wanted, Junior Draughts- MAN, aged 16 to 18, for Constructional Engineers' Office, London. Write, stating experience and salary required.—J. 732, c/o DEACON'S, Leadenhall Street, E.C. 3. U 199

Machine Tool Draughtsman WANTED, experienced in the design of Capstan and Turret Lathes.—Apply, by letter, giving full particulars of qualifications and wages required, to Messrs. H. W. WARD & CO., LTD., Dale Road, Selly Oak, Birmingham. U 188

Wanted, Foundry Foreman, thoroughly experienced in high-class light engine castings; must have special knowledge of gun-metal mixtures for heavy pressures, and all Admiralty test requirements; about 60 hands employed; none but thoroughly reliable experienced men with good references need apply. Good position for suitable man.—State age, wages, and full particulars to A. G. MUMFORD, LTD., Culver Street Engineering Works, Colchester. U 107

Cottage Building—outside LONDON—Opening for Gentleman as Apprentice, reside with Young Builder.—Address, U 167, Offices of ENGINEERING.

Articled Pupil.—A Civil Engineer has VACANCY for well educated young gentleman as PUPIL. Good practical and theoretical training. Interesting works in hand. Premium required.—Address, U 143, Offices of ENGINEERING.

SITUATIONS WANTED.

Buyer.—The Manager of a large Engineering Works' Purchasing Department, who has an exceptionally wide knowledge of the Markets of the Country, DESIRES to Negotiate NEW APPOINTMENT.—Write, Z. M. 613, care of DEACON'S, Leadenhall Street, E.C. 3. U 154

Engine Works Manager, now free, with experience in fitting out large Engine Works with Machine Tools, Hydraulic Plants, &c. Wishes to take up Valuation of Machinery Plants, also inspection and testing of Materials.—Address, U 180, Offices of ENGINEERING.

Engineer, 32, Shops, D.O., technical, commercial, internal combustion, printing, rubber, and general engineering; good education; adaptable, inventive, energetic, enthusiastic, diplomatic; £350.—Address, U 111, Offices of ENGINEERING.

Engineer, 29, Apprenticeship. Technical Training, 2nd Class B.O.T., 8 years sea. 3 years 2nd Eng., 18 months D.O.; 11 years' Oil Fuel experience. Thorough knowledge Marine Engineering. Strict teetotaller. Seeks Appointment. Excellent testimonials.—SEARLE, Derwentwater Road, Gateshead. U 159

Engineer (38), A.M.I.E.E., electrical and mechanical, practical experience, electric traction, colliery, power station, works plant and electrical distribution, installation and maintenance; 13 years with leading electrical contractors. Disengaged.—U 183, Offices of ENGINEERING.

Engineer (39) 1st class B.O.T. Certificate, M.T.N.A., well educated, 10 years' supervision, Ship and Machinery repairs, new Vessels, Cargo and Oil Tankers, Turbine and Diesel Machinery, Oil Fuel Plants, Surveys and Reconditioning, Correspondence. At present Asst. Superintendent large Shipping Company, DESIRES better POSITION. Highest references.—Address, U 192, Offices of ENGINEERING.

Shiprepairing, Engineering and SALVAGE.—Gentleman (32) experienced all branches, practical, technical and commercial, DESIRES OPENING as assistant to Dock Manager, Supt. Engineer or Consultant. Excellent references.—Address, U 198, Offices of ENGINEERING.

Engineer, 23, Mechanical. M.C., B.Sc. (Hons.). Good general engineering education, works experience, DESIRES START on commercial or production side. Will start without pay for necessary experience.—Address, U 203, Offices of ENGINEERING.

Engineer, 38, Desires Charge Steam, Gas, or Electric Plant. Extra B.O.T. Certificate. Experience of Boiler Inspection. Salary £350.—H. S., 42, Pelham Road, Wimbledon. U 205

Engineer, 1st B.O.T. Certifi- cate, DESIRES CHARGE PLANT or suitable employment. Age 31. Ex-service.—Address, U 204, Offices of ENGINEERING.

THE INTERNATIONAL RAILWAY CONGRESS AT ROME.

(*Continued from page 547.*)

ELECTRIC TRACTION.

No less than seven reports on the subject of electric traction were considered by Section II, which sat under the presidency of Mr. George Gibbs, Chief Engineer of Electric Traction of the Long Island Railway, United States of America.

The most complete discussion of the question of electrification was undoubtedly presented in the report on this subject by Mr. George Gibbs, who dealt with America. While other reporters had given summaries of the history of electrification in their respective countries, Mr. Gibbs, having a rather wider field to work over in which no particular system had been adopted to the exclusion of others, was able to compare to some extent the characteristics of one with another. The report is not too full of technical detail, and is rather of the nature of a summary than an endeavour to substantiate facts by masses of data. Yet with the reputation of Mr. Gibbs behind it, we are sure it may be taken as an honest endeavour to arrive at the real essentials.

Since 1910, when Mr. Gibbs reported to the Berne Congress, the aggregate mileage equipped electrically in America had increased from 873 track-miles, to 1,526 miles in 1920. Practically no new mileage was now under construction in America, though important projects were planned to be undertaken when financial conditions should admit. Practically all kinds of service had been successfully met, but electric traction had been primarily adopted to secure better operating conditions, as, for instance, to obtain an increase of capacity in terminal or tunnel working, to increase capacity on heavy gradients, to foster business in suburban work, to make use of hydro-electric power where that was cheap, and coal dear. In all cases he considered the direct operating savings plus the indirect advantages had been sufficient to justify electric traction. In discussing the various systems Mr. Gibbs stated that though third-rail direct current had been perfected to a greater extent than other systems, it was now considered obsolete in America. The overhead system presented many advantages, but it was essentially a device for small currents, and therefore its use involved raising the voltage. With single-phase alternating current, 11,000 volts to 16,000 volts had been successfully used and 3,000 volts for three-phase. The complications of the double conductor in the latter case restricted the adoption of that system. Three thousand volts appeared to be the maximum possible with direct current; something lower than that would be really better, though this voltage was too low for really satisfactory collection from an overhead conductor.

Proceeding to the question of type of locomotive Mr. Gibbs considered that the type with motors geared direct to the axles was suitable only for slow speeds. The centre of gravity was low and unsprung weight high. Side shocks were severe. Geared motors with quill drive were better, but had not proved satisfactory in heavy service. The New York Central type with armatures on the axles was rather complicated and unfavourable for tracking, and its use was limited to track construction of the heaviest character. The output was low at low speeds. The same type, but with quill drive, was an improvement, but was not economical as regards first cost, while the centre of gravity was still very low. Gearless motors with rod drive allowed the most desirable arrangement and weight distribution for good tracking qualities, while the geared motor and rod drive offered the most flexible and promising solution for passenger and freight work. Side rods were desirable in all types.

The question in the United States appeared to be narrowing down to a choice between 3,000 volts direct current and 11,000 single-phase alternating current, but it was, in Mr. Gibb's opinion, too early to decide definitely on adopting either of these as a standard. The question was unfortunately being complicated by commercial considerations, and he hoped the matter would not be forced prematurely to a conclusion. On the whole he inclined to high-tension alternating current. What was most wanted was a system flexible in the direction of subsequent extension. No reliable data of general application were yet available with regard to costs. As regards cost of installation high-tension alternating current had some advantage over high-tension direct current. Inductive effects were more costly to overcome in the case of alternating current currents, but progress was being made in this direction. Electric traction had proved astonishingly reliable and serviceable. The report concluded with short descriptions of the important American systems and with tables of particulars.

M. E. Huber, of the Swiss Federal Railways, was responsible for a report on railway electrification in Switzerland. In this he recorded that at the beginning of 1921 altogether about 1,121 miles of lines were electrified, while other mileage was in hand. Of the length named some 700 miles represented light railways and of the remainder 20½ miles were worked with direct current, 82 miles with three-phase, and the balance on the single-phase system. The direct-current lines had been dealt with at a previous congress (Berne, 1910). The three-phase lines included a 33½-mile section converted during the war to utilise the output of the station normally supplying the Simplon route, which was practically closed for some time. This section would ultimately be changed to single-phase. Single-phase had been adopted as the standard for the country as a result of a report by a commission issued in 1912 recommending 10,000 volts to 15,000 volts with a periodicity of between 13½ and 16⅔. The alterations involved to telephone and other wires would have been required in the adoption of any electrification scheme, as they were placed so close as to interfere with the execution of the work; when the change became necessary they were placed underground. The problem of regenerative control having been solved, reduction in wear was expected, with greater comfort to the passengers, and some saving in current. M. Huber proceeded to relate the history of single-phase traction in the country, this development having been accelerated by the need of converting rapidly from coal to water power during the war, and adopting a system of which local engineers and works had had experience. The country had been mapped out for a comprehensive scheme arranged to obtain a satisfactory balance between the various generating stations. A long list of particulars of the single-phase systems is given. As regards results the figures available are not very complete. For the Simplon line the consumption has averaged 51 watt-hours per ton-kilometre. On the Rhaetian Railways it has averaged 50·7. The latter, however, are light lines and not comparable with the former. Other systems had not been at work long enough for any results to accrue. On the Simplon line consumption appeared to be about 10 per cent. higher in winter than in summer. The difference was higher on the Rhaetian lines, but that was in part probably due to heating the trains by electricity, whereas on the Simplon route steam heating was employed. On the Simplon route maintenance cost about 17 per cent. less for electric locomotives, as compared with steam engines of half the power. The question of system is considered to be definitely settled for the country.

So far as Great Britain and Holland were concerned, the subject of electrification was in the hands of M. Van Loenen Martinet, of the Netherlands State Railways. In this report, M. Martinet reviewed the position as regards electrification in this country, referring to the appointment of the Electricity Commissioners and the various steps taken to bring the developments, following this appointment, into the range of practical affairs. As M. Martinet's report was published in the association bulletin of October last year, it is necessarily not quite up to date; our readers, however, are familiar with the progress made since then, and we need not go further into this subject now.

In Holland most of the current is three-phase at 50 periods, generated at 10,000 volts. A few high-tension systems exist supplying at 50,000 volts. As a result of a report by the Dutch Committee on Railway Electrification it had been decided to adopt the 1,500-volt direct-current system for operating. M. Martinet's report gave in an appendix the reasons which led the committee to decide on this system. Among these were that gradients scarcely existed in Holland; that if single-phase or direct current were generated by the railways there would be little difference in efficiency and costs, the difference being very small for lines of medium traffic density and length; that as traffic increased and the distances were reduced the direct-current system had the advantage; the alternating current motor appeared likely to remain more complicated than the direct-current; and that although overhead collectors for 1,500-volt direct current presented some difficulties these were not insuperable by any means. The report gave a number of statistics relating to breakdowns on the Rotterdam-The Hague-Scheveningen Line, with 10,000-volt 25-cycle supply, due to faulty insulators, and showed how these failures had been reduced by improvement in design from a maximum of 25 in 1912 to nil for the period 1914–20.

The question of type of locomotive had not been seriously considered in either country up till the present. The multiple unit motor car at present sufficed for conditions in Holland.

The Electric Traction Report for Scandinavian countries by M. J. Öfverholm, of the Swedish State Railways, consisted more of an historical record than of a discussion of experience or practice. The report reviewed the position as influenced by the absence of coal in those countries, and, except for Denmark, the ample supply of hydraulic power. The sequence of electrification of various lines was recorded, the fact being mentioned that in connection with the Kiruna-Riksgränsen line, which had been worked since 1915, only the contact lines and locomotives had given any trouble, but even these defects had been remedied and the service now was thoroughly reliable. It had been decided to proceed with electrification as opportunity offered, dealing as far as possible with the lines in groups with due regard, first to those on which imported coal necessitated a larger expenditure. The presence of supplies of wood made it less urgent to electrify some districts. The districts in Sweden having the largest coal consumption were the Stockholm-Göteborg, the Järna-Malmö-Trellaborg, and the Stockholm-Bräcke lines. These would be next undertaken. No difficulty was anticipated with regard to water power, but the fall in the price of coal and the difficulty of raising money had momentarily caused the postponement of further work, though some lines in hand were likely to be completed this year. In Norway development also began on lines with heavy mineral traffic, but the Kristiania-Drammen line of the State Railways, was being electrified, and this would carry both express and heavy suburban traffic. For this the station voltage would be 60,000 volts, transformed to 16,000 volts.

M. Sabouret's report, which nominally covered all countries except nine, was virtually confined to the position in France, with a short reference to Spain. In France the three companies of the Paris-Lyons-Mediterranean, the Midi and the Paris-Orléans, had programmes which involved the electrification of 5,000 miles of railway in about twenty years. In view of these proposals the Minister of Public Works had appointed a commission, and as a result it had been decided that the standard system for the country should include generation and distribution of three-phase 50-cycle current, transformed to 1,500-volt. direct current, the locomotives to be fitted with two collectors, one for use on third rail systems and the other for collecting from an overhead conductor. M. Sabouret reviewed the historical development in France which ultimately led up to this large programme put forward by the three railways named, culminating with a visit by the commission above referred to, to the United States for the purpose of investigating the working of direct current systems in that country. As a result of this mission although the majority of the members who went to America favoured the single-phase system, they returned unanimously in favour of high tension direct current. It was quite sufficient, M. Sabouret considered, for the system to be standardised for a country, as locomotives did not cross frontiers. Direct current

caused less trouble in connection with telegraph lines, and regenerative control was of more value with direct current, as it could be brought into use over a larger range of speeds, whereas with other systems a definite speed had to be attained first. In connection with the use of two or more locomotives to a train complete unison was required on the part of the drivers. This, it was thought, could be obtained by a system of electrical control worked out by the Orléans Company. Continuous current allowed of a more flexible type of locomotive. The three companies would be able to merge their generation and distribution schemes so that one plant could supplement another, while all would probably participate in hydro-electric developments on the Truyère. A voltage of 1,500 was about the limit it was possible to use with the third rail, which form of conductor, incidentally, had the recommendation of being a product of France, whereas copper would have to be imported. The type of third rail had not been decided upon. In his reference to Spain M. Sabouret pointed out that the lines electrified there were converted to increase their capacity.

Generally, as regards results, figures were not yet forthcoming showing the saving, if any, from electrification. In many cases the conversion had been undertaken for other considerations.

Sig. Alfredo Donati's report on Electric Traction referred solely to Italy, and dealt largely with the historical aspect of the subject. Sig. Donati, after a reference to the third rail 650 volt. system adopted for the Milan-Varesi line in 1901, went on to discuss the three-phase system and its application to later schemes. The voltage adopted was 3,000 and the periodicity 15. That was a much lower periodicity than the usual supply by commercial companies, but the lower frequency resulted in a lower voltage drop and required for the primary main a smaller section of conductor. However, in certain new schemes it had been arranged to utilise 45-cycle supply taken from local companies.

The lines so far electrified had been converted on account of having reached the limit of capacity for steam working. Other lines are in hand, and when completed it was expected the saving in coal would amount to 1,250,000 tons per annum. The supply of current would generally be purchased, but the Italian State Railway Administration was itself developing certain important hydro-electric installations. Most of the companies produced 42 or 50-cycle current; this was transformed for the railways, though some stations generated current, both at 42 and at 15-16 cycles, the latter being for the railway supply. In the first installations the transformer sub-stations were small and frequent, the trolley wires consequently being small. The tendency now was to increase the distance between, and the capacity of, sub-stations. In order to get over the difficulty of costly reserve plant at sub-stations a type of mobile transformer plant had been developed which could be run to any point required. These plants were mounted on two six-wheeled bogies and had a capacity of 2,250 k.v.a. up to 59,000 volts. To work these it was necessary to have the primary mains alongside the railway. The trolley wire should not be too large in section or it lacked flexibility at high speeds. The present limit between sub-stations lay in practical conditions of working and not in technical difficulties. The double wire necessary for three-phase system appeared more complicated than it really was. Insulation had not given any serious trouble. Suspension was by springbows hung from cross arms on posts. The posts were placed 98 to 115 ft. apart. This type of suspension was cheap and simple to erect and inspect. No riveting was required.

The locomotives were limited as regards axle loads to 15 tons, and to a tractive force of 10 tons. They are designed so that different types have at least one speed in common, so that they may be run in double-headed trains. No trouble had arisen in control through the use of double or triple traction, on account of small differences in driving wheel diameter. Trains kept well to the time-table. Regenerative control was employed and effected considerable economy. The economic results had been entirely favourable. The difference from an economic point of view between direct-current and three-phase working was almost negligible. The cost per electric train-kilometre in Italy at present was about 2·40 lire. Only 16 per cent. to 17 per cent. of that figure could possibly be affected by any advantage one system might have over another. The question of having one system for the whole railway was of more importance than the actual system adopted.

There was probably a greater attendance at the discussion of these reports than at any other technical functions of the Congress. The discussion began on April 20 and only terminated on April 24 owing to the pressure of other business.

M. Gérard read the final part of his summary of the various reports, and the five paragraphs it contained were taken one by one. The first stated that the question of electrification to be adopted, did not turn on which system was the best under all circumstances, but which was preferable for any particular case. Both M. Huber and Sir Philip Dawson agreed with this, the latter remarking that with the consent of the Ministry of Transport, a three-wire 3,000 volt D.C. system was to be adopted for the South Eastern and Chatham Railway. It appeared to be the general feeling of the meeting that it would be inadvisable to pronounce in favour of any system as against the others, as each had its special advantages, and any attempt at standardisation now would retard progress. Signor Lanino, representing the Italian Government, justified the multiplicity of systems adopted in Italy, and held that it was much more important to standardise couplings and draw-bars than to standardise electrical systems for railways. M. Sabouret, however, argued in favour of a standard system, and said that this had been attained in France. Mr. Josiah Sayers, of the Great Central and Midland Railway Joint Committee, held that, in Great Britain at any rate, one of the most important factors in determining what system of electrification should be adopted was the question of inductive interference with telegraph and telephone wires. In England the Government had a legal right of way for these wires along railways, and the railway companies had to allow the wires to be used free from disturbance. Mr. Huber said that in Switzerland the public telegraph and telephone wires had in many cases been removed from the vicinity of the electrified tracks, but in many cases this could not be done. The choice of system in Switzerland had not been governed by the possibility of removing the wires.

An American delegate made an emphatic protest against an inference in Mr. Gibbs' report that the large electric supply companies in the United States desired to bring any pressure on the railways concerning the system of electrification to be adopted. He was authorised to say that the companies were perfectly ready to furnish any kind of current and any voltage which the railways might ask for, and they had neither reason nor wish to dictate as regards system. Later, the discussion ranged over the standardisation of records, the difficulties in the way of this arising from the practical impossibility, in some cases, of separating the figures relating to the electrified part of a line, from those relating to the other part. The report advocated the adoption of some common unit of traction for purposes of accountancy, a virtual ton-kilometer, being suggested, this term denoting the energy required to draw a ton over a kilometer on a level straight track. Sir Henry Fowler questioned whether it was possible to define any such unit in a way which would have any practical value.

The outcome of the discussion up to this point is given in the following resolutions of the Section, which we quote *in extenso*.

(1) The Congress recognises that it is no more possible now than in the past to recommend any particular system of electric traction as applicable to all cases. There are several systems to choose from, all of which have proved their value under the severest operating conditions, but the Congress recognises that these systems are all susceptible of considerable further improvement.

(2) The Congress agrees on the uselessness of standardising the nature of the current in the contact wire, on account of the ease with which locomotives may be changed at the frontiers of different countries.

(3) It is to be desired that the methods used for collecting and publishing the statistical data concerning electric traction be well defined and standardised. With this object, Section II, expresses a wish that a Special Committee of the Association be entrusted with the working out of a programme dealing with each point in detail so that in the future comparisons may be made by means of entirely comparable figures.

The remainder of the discussion was devoted to the questions contained in the final paragraph of M. Gerard's summary, and most of the remarks made were concerned with the collection of current by locomotives, and the difficulties experienced with the collecting apparatus. Experience on the Illinois Central Railroad had shown that it was desirable to duplicate the contact-wire on the main lines where the traffic was heavy, when the voltage did not exceed 3,000 volts, as a single contact did not give satisfaction with the heavy currents involved under such circumstances. Sir Philip Dawson said that the wear and tear of the contact wires on the Brighton line was insignificant at places where no current was taken and where there were no fumes from steam locomotives. Abnormal wear had been avoided by the elimination of "hard-points" in the overhead wire, and generally speaking, it was found that wear increased in a greater ratio than the current collected. The double conductor system of the Chicago, Milwaukee and St. Paul Railroad was stated to be behaving extremely well, both as regards wear and tear and absence of sparking. A Swedish delegate instanced the collection of a 11,000-volt current from a contact wire having catenary suspension with suspension points at every 17 metres, without trouble, and it was stated that practically no wear was found on the Paris Nord-Sud Railway, where the current collected usually reached 1,000 amperes at 600 volts.

The simple transverse suspension, as used for the overhead wire on Italian railways was said to give excellent results at speeds up to 60 miles per hour, and on a three-phase line near Turin Signor Donati mentioned that the delays due to the contact wire only amounted to 80 minutes per month out of a total of 2,080 minutes delay due to other causes. Mr. J. Sayers pointed out that the only way of obtaining a contact wire without "hard points" was to increase the number of points of suspension, and this view led logically to the adoption of catenary suspension. The president agreed with this argument, and considered that for fast trains and heavy traffic catenary suspension was the only method that was likely to be satisfactory.

On the question of frequency of alternating current railways, the point seemed to be whether there was any great advantage in the railways adopting 50 cycles, with a view to using a frequency which was already standard for industrial purposes. M. Huber, whose experience in these matters is very great, appeared to think that the sudden and irregular demands for current by the railways would give rise to very serious difficulties if the railway systems were connected either directly or through transformers with the industrial systems. Signor Donati thought that regulating devices might be designed to overcome such difficulties. The question was not considered of serious importance in countries with great industrial development, but in places like Southern Italy, as Signor Lanino pointed out, the problem of combining the industrial supply of electricity with the traction supply for the railways urgently demanded solution. The abandonment of the single-phase system in favour of the split-phase system on the Norfolk & Western Railway of America was explained as due to difficulties arising from the starting of heavy trains, but M. Huber stated that some of the Swiss single-phase railways were working under quite as difficult conditions as the line in question, and the single-phase locomotives did the work as easily as steam locomotives.

The last part of the discussion was devoted to rather more detailed points in connection with electric traction. It was stated that in

Switzerland the limit of tractive effort of the locomotives had been raised from 10 to 15 tons, and that two locomotives, one at each end, were used to haul a 800-ton train up the St. Gothard gradient. A limit of 15 tons for the tractive effort had also been reached in Italy, where the adhesive weight was restricted to 60 tons. The advantages and disadvantages of trailer cars aroused a fair amount of argument. The President said that in American practice the use of trailer cars had been entirely abandoned, and that the problem of shunting in terminal stations was thereby greatly simplified. The French State Railways, on the other hand, has started without any trailers, but had found that the addition of cars without motors had caused no difficulty. The same conclusion as to the practicability of using a certain number of trailer-cars had been come to on the Italian Milan—Varese third-rail line. The last point of any importance to be discussed was the question of the disturbance of telegraph and telephone circuits by the inductive effects of the railway current. In Switzerland some telegraph and telephone wires had had to be moved, and others put underground. M. Bachellery, of the Midi Railway of France, said that during the trials of single-phase traction on that system, he had come to the conclusion that it was quite possible to suppress all inductive interference without moving the lines, although the cost of the necessary apparatus was considerable. With the first introduction of three-phase current on the Italian State Railways, the Government had removed the telecommunication lines, and Signor Lanino held that that was the safest thing to do. He did not think that disturbances would be avoided by the use of direct current for traction. Other speakers, however, said that the experience of the Chicago, Milwaukee & St. Paul Railroad in America showed that direct current caused no disturbing effect, even though a short circuit should occur. The final conclusion regarding the matter was that while technically it is possible to neutralise the inductive effects of the traction current, in practice this would involve an expense to be considered.

MAINTENANCE AND SUPERVISION OF TRACK.

The subject of Maintenance and Supervision of track (in Section I) was reported on by Messrs. Epes Randolph and Earl Stimson for America, Mr. C. J. Brown for British railways, and by Sig. J. Barbieri for all other countries.

The American report consisted of two separate sections prepared respectively by Mr. Epes Randolph of the Southern Pacific Company of Mexico, and by Mr. Earl Stimson, chief engineer maintenance of the Baltimore and Ohio R.R. The report of the former was prepared for the 1915 congress, while the latter is complementary and has only recently been completed. Mr. Randolph in his report pointed out that notwithstanding changes in regard to refinements in maintenance, government interference, the introduction of efficiency experts and so on, the organisation had not changed materially between 1900 and 1914. Mr. Randolph recommended the Divisional system of organisation in which the maintenance of way department was one of three sections under the operating department. This required an engineer of maintenance of way responsible to the general manager or system official in charge of operations, and below him general superintendents of grand divisions, division superintendents of operating divisions, and division engineers with under them supervisors or roadmasters and section foremen. The latter were in charge of section gangs. The division engineer had from 100 to 700 route miles, the supervisor from 55 to 150 route miles, and the section foreman 8 miles or so of track; 5 miles of sidings and 15 switches were equivalent to 1 mile of track. The introduction of the motor trolley had increased the mileage a section gang could look after; their adoption enabled the men to reserve their energy for useful work, and their advantages had been demonstrated beyond question. Section gangs ran out at about 1 man per mile, though Mr. Stimson gives 1 to 2 men per 2 miles in winter, and 1 to 3 men per mile in the working season. Relaying was by special gangs temporarily recruited; section gangs should not be drawn on for this work. For rail renewal only a gang of 30 men under a foreman was used. For sleeper renewal, &c., in addition an extra gang of 50 men and foreman and assistant should be organised. The class of labour was usually poor. Supervisors should inspect their district so that the whole was covered three times a month. This should be done on foot or by trolley—not by train. Section foremen should pass over their sections once a week. Track walkers were employed on patrol duties.

As regards time-keeping, time should be booked by section foremen daily, and time sheets sent through fortnightly or monthly to the Division engineer, for making out the pay rolls. Mr. Randolph recommended the Division store in charge of an official responsible to the general storekeeper. Material could be effectively distributed by a supply train working out periodically from the division stores and distributing to the point where the stores were to be used. The same train could collect returned material, scrap, excess stocks, and so on. Piece or contract work was not to be recommended. The system was antagonistic to characteristics of permanency, lasting stability and safety. Once work had been accepted, responsibility for it ceased, whereas with regularly employed foremen there was a personal responsibility for the future. In order to increase economy the use of mechanical appliances should be developed. These included combined centre and side unloading cars, power machines for drains, cuts, &c., rail handling machine and so on.

Mr. Stimson's more recent report, though agreeing with Mr. Randolph's, makes recommendations on some points in an opposite sense. Though admitting that a large proportion of American roads employ the divisional system, Mr. Stimson urged the use of the departmental system as providing at the head a specialist technical official. He considered also that this system was better adapted to expansion than the departmental, from which it appears that the respective merits of the two systems are as far from being finally settled as they ever have been. On the matters of the section gang, extra gangs, track inspection, accounting and stores, Mr. Stimson's report confirmed the previous one. On the matter of economics of track labour, however, Mr. Stimson is in favour of a system based on units of performance which are standardised for the principal items of work. This system appraises the work done according to recognised standards, and adds a bonus or premium on output. To enable this system to be worked, all the sections have to be reduced to a standard taken as an equivalent mile of first main track. For instance, 12 points and crossings = 1 mile; 10 railroad level crossings = 1 mile; 4 miles of ditches = 1 mile, and so on. After this, a relative value is given to parts of the work. Standard schedules are drawn out with great care, suitable allowances being made, *e.g.*, an addition of 10 per cent. for detention in going to and leaving work, and so on. The actual performance is compared with standard performance and the gang is paid accordingly. Ordinary rates are guaranteed, but the bonus is additional, if something less than 100 per cent. efficiency, or more is attained.

The next report presented under the heading of "Maintenance and Supervision of the Track," was submitted by Mr. C. J. Brown, of the Great Northern Railway of England. Dealing with supervision Mr. Brown stated that the ordinary organisation on British railways consisted of a chief engineer and assistant in charge of maintenance, with divisional engineers in charge of districts averaging about 250 route miles or 450 track-miles. Each divisional engineer had usually a chief inspector who supervised permanent way inspectors who had charge of, on the average, 37 miles of line. The latter were required to inspect their whole district in periods which varied between one week and three months. Probably, if the line was walked over, this period should not exceed one month, or if trolleys were used, one week. Each inspector's section was cut into short lengths of 1–4 miles, and each of these was in charge of a ganger and from two to five men. The number averaged out at about 1·26 per mile, though in India it rose to 2. In South Africa it was 1 and New Zealand 1·65. On British lines the road was walked over twice a day. No change in this practice is foreshadowed.

Renewals on British roads were carried out by special gangs. In some cases each inspector had his own gang; in others general gangs work where required. Commonly a small nucleus permanent gang was maintained, strengthened by temporary labour. The renewal gangs under a ganger and possibly a sub-ganger varied from 20 to 50 in strength; in India they run to 400. On some lines in India labour was contracted for. At one time the Lancashire and Yorkshire Railway contracted for relaying, but the practice had not been adhered to.

Between 1900 and 1914 advances in wages represented an increase in maintenance costs of between 6 per cent. and 30 per cent. Advances in prices of materials in that period represented between 6 per cent. and 50 per cent. increase. Since 1914 the cost had gone up more rapidly. This had been due partly to the shorter day which had required additional staff in proportions varying up to 1 in 13. In order to offset the shorter day, several companies had reduced the number of inspections from 2 to 1. The total increase in maintenance costs over 1900, ranged between 180 per cent. to 300 per cent. for wages and 130 per cent. to 300 per cent. for materials. Relaying, which cost between 160*l.* and 470*l.* per mile in 1900, in 1920 cost from 405*l.* to 1,200*l.* In order to counteract these advances some companies were trying rails of special steel, *e.g.*, sorbitic, high silicon and manganese, in specially bad places; others were adopting statistical methods of observation, decentralisation, or the use of labour-saving appliances. So far, however, no serious steps had been adopted. In Australia, on one line several small gangs had been replaced by a large one. On some lines cranes, &c., had been introduced for handling materials. Temporary telephones used on the track enabled work to be done in the week which otherwise could only be done on Sunday. Sections of track were sometimes prepared alongside and lifted by cranes into place. Boring and adzing was done at depots. Electric and pneumatic shovels had been tried, but were awkward to handle on a busy line, and were not suited to the present system of organisation using small isolated groups. The concentration of the small gangs into one large one covering a considerable stretch of line appeared to offer the necessary field for the use of more labour-saving appliances. On the London and North-Western Railway, work was expedited by the means of a rail remover and layer, and a rail pick-up and scooter. Shovel packing was now used in preference to the use of beaters. This lessened the work of packing and enabled the gang to attend to other duties.

In ballasting, hopper wagons of from 6 tons to 25 tons capacity were used, but not universally, some lines keeping to a low side ballast wagon which could be also used for rails and sleepers, &c. Rail wagons carried from 15 tons to 40 tons of rails though some roads used ordinary bolster wagons. Ballast ploughs and spreaders were in use. Ballast trains were more economically worked if placed under a central authority, and there was a good deal to be said for obtaining ballast guards from the traffic department as required. By reorganisation of the present system of small units, it appeared that a good deal might be done to introduce labour-saving methods and so reduce the cost of maintenance. Contracting was not to be recommended.

The report for all countries except Great Britain and America on this topic, was submitted by Signor J. Barbieri, of the Italian State Railways. Sig. Barbieri said it was difficult to differentiate between the temporary increase in costs which would pass as conditions improved, and permanent increases. As a result of his enquiries it appeared that the departmental system was most in vogue, with divisions, sections and sub-sections or their equivalents. Divisions varied from 310 miles to 800 miles, sections 37 miles to 185 miles, and sub-sections 6¼ miles to 56 miles. There was some tendency to increase the length of districts and to abolish some of the sections. The best system appeared to be sections of about 185 miles directly responsible to the head of the department. Maintenance officials should also be responsible for the other engineering work except

in special cases. The lengths entrusted to gangs ranged from 2½ miles to 7½ miles of single line, the gangs ranging from 2 men to 10 men with a ganger. An inspector controlled up to five gangs. Small gangs were kept for maintenance and several were grouped, or temporary labour engaged for special work. If the length of track entrusted to gangs increased they must be furnished with machines or trolleys for getting about. Contracting was employed by some administrations, but usually only for ballast cleaning and re-laying. On the Italian system work had been entrusted to small contractors or co-operative societies. No systems had entrusted the work of relaying to ordinary gangs on piecework. The Italian State system, however, introduced before the war a minimum daily task per man with a bonus on this being exceeded. It answered well, but had not been resumed since. Economy might be secured by grouping the small gangs. Although contracting was not much in favour, with good supervision it might procure favourable results. The present-day output per man did not correspond with the increase in pay. The supervision customary with contractors would tend to counteract that.

The weight of rails was increasing to 101 lb. for main lines and 110½ lb. for tunnels. Reinforced sleepers were being tried, and seemed to promise well. Administrations ought to turn their attention to interesting the staff in the economic use of tools, &c., salvage of condemned material, and so on. The greater use of machines was recommended. These were only possible if organisation enabled them to be used on a large scale. Compressed air rammers had the disadvantage of noise which necessitated a better look-out. Inspection of the line was best carried out by "road guards," or patrols, who could take from 8 miles to 10 miles a day, walking over the line and returning, if necessary, by train.

The discussion on these four reports, although somewhat protracted, did not result in any very striking recommendations, the conclusions being of a general nature, and such as would be accepted without comment by any railway engineers. It was recommended that the work of the maintenance staff should be under the close supervision and systematic control of the responsible engineers, who should reorganise the work wherever possible to enable the fullest use of mechanical labour-saving appliances. This could often be effected by replacing a number of small gangs by a larger gang stationed at some convenient centre and equipped with means of rapid transport. A change of this nature would permit of better supervision, and by increasing the efficiency of labour, it would enable a reduction to be made in the total number of men employed. Economical maintenance, it was further pointed out, was a matter largely controlled by the original construction of the track, which should be well laid in the first instance and of ample strength. Some companies found it advantageous to arrange with contractors for track maintenance, the advisability or otherwise of this practice being dependent upon local circumstances. A proper system of inspection should be adopted to ensure the quality of materials used for maintenance. To reduce expenses it was considered practicable, in many cases where legislation did not control matters, to reduce the number of level crossing keepers, or even to abolish them entirely. Furthermore, a single daily inspection of the track was considered to be the maximum necessary, and less frequent inspection was sufficient in many cases.

(To be continued.)

JOURNAL OF THE CONCRETE INSTITUTE.—The April number of the *Journal of the Concrete Institute*, a copy of which is just to hand, contains a brief report of the annual general meeting of the Institute held on April 27, and mentions that a detailed report will be published later. It also reprints the first part of a paper by Mr. H. Kempton Dyson, entitled "What is the Use of the Modular Ratio?" and includes some notes on new buildings in the London district in which concrete is being used. We have also received from the Institute a copy of the report of the council for the session just concluded. The name and address of the secretary are Captain M. G. Kiddy, F.I.S.A., Denison House, 296, Vauxhall Bridge-road, London, S.W. 1.

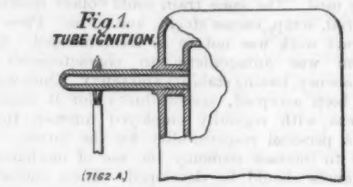
AUTOMOBILE IGNITION.

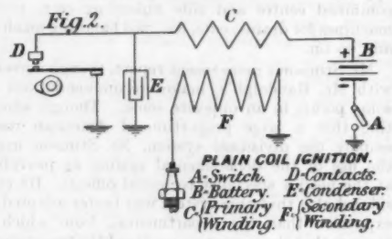
A Review of Systems Past and Present.

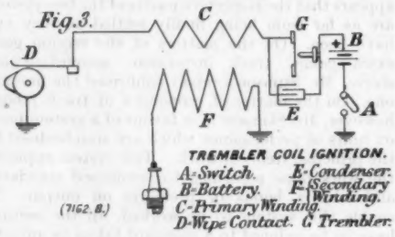
By CHARLES BAXTER, F.R.M.S., A.M.I.Mech.E., A.M.I.A.E., &c.

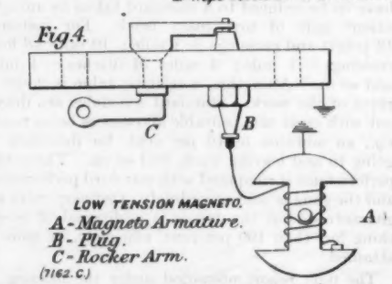
FROM time to time, one hears, that yet another automobile manufacturer has been added to the growing list of those abandoning the magneto in favour of coil and battery ignition; and as this trend of evolution interests everyone, from the designer to the user, it is hoped that a general survey of ignition history, along with a few practical and technical observations thereon, may not prove out of place.

Many and weird have been the devices, used and suggested, for the purpose of starting ignition in the cylinder of an internal-combustion engine,









but for the purpose of this article it is proposed to leave out such types as the "naked flame" which could not be taken seriously, and was never used in automobile practice.

When the writer first came into contact with the subject, it was in a very unsatisfactory state, being by far the weakest part of the vehicle. When tyres, gears, clutches and a host of other things were not giving trouble, the ignition system could always be relied upon to fill the gap, and provide some baffling mystery, causing endless delay. Many of the troubles experienced could be directly traced to poor mechanical design, and what to-day would be considered bad workmanship; but the scanty electrical knowledge, extant at that period, no doubt contributed to the large amount of trouble experienced.

One of the earliest ignition systems, and the only one of a non-electrical nature to be used for car purposes, was by means of the hot tube, an example of which was to be found on a very well-known make.

Tube.—This was an adaption of what was then everyday gas-engine practice, and consisted of a blank-ended tube, heated by a lamp, the open end of the tube being screwed into the combustion chamber, as shown in Fig. 1. On the compression stroke the mixture was forced into the hot portion of the tube, ignition thus being started. The system worked better than one would expect, some slight adjustment in the firing point being obtainable by shifting the burner along the tube one way or the other. Oxidation, however, was very severe, and so iron for the tube soon gave place to platinum, which in gas-engine practice was replaced by porcelain, a firing valve being added in large sizes to control the point of the stroke at which the mixture was admitted to the tube. This system was soon abandoned by the firm in question in favour of electricity, but it is still in use to-day on many thousands of stationary engines, where the danger by fire, and inconvenience due to waiting for the tubes to heat up, does not apply to the same extent, and where the trouble of the bunsen being blown out by the wind is non-existent. All the other cars known to the writer were fitted with some form of electrical device, principal amongst which was the "plain coil," as fitted to the De Dion tricycle.

Plain Coil.—This simply consisted of an accumulator, contact breaker, plain coil, switch and sparking plug, arranged as shown in Fig. 2; the whole being fairly satisfactory with the exception of the accumulator, which in those days was a very poor affair, it being quite a common occurrence to find that when the spare one was put on, after exhausting the one in use, that that also had become run down for some unknown reason.

With this system the battery is dead short circuited if the points are closed and the engine stationary, so that if engines were not in good tune, much current was wasted in getting a start, and batteries were often ruined, by the switch being left on after stopping on the throttle; no warning or switching-off device being fitted. The spark with this system was good and accurately timed and the primary current, designated IB, could not rise to any serious value when the engine was running, owing to the self-induction of the coil.

Trembler Coil.—In order to provide a system which would be more foolproof, a trembler coil was substituted for the plain one, and a wipe contact for the make and break (see Fig. 3), the great advantage derived from this change being that audible warning was given, should the switch be left on, and that in no case could IB rise to a dangerous value, due to the intermittent contact of the trembler.

It is with this system that many people gained their experience of coil ignition, and for that reason the writer is not at all surprised to see a proportion of them shy of the reintroduction of the coil, for although the trembler greatly facilitated fault-finding and obviated the damage to accumulators, accumulators still remained an uncertain quantity, and the trembler introduced three other troubles, namely: vibrating contacts, which often stuck and needed frequent attention; a wipe contact, which is an uncertain affair at any time; and a coil that possessed lag; which means that after the wipe contact closed, a certain lapse of time occurred before the trembler operated and the spark took place. The majority of multi-cylinder cars were fitted with a coil to each cylinder, and the seriousness of the uncertain contact and lag can then be easily seen, for with the ignition lever in any position, all cylinders were igniting at a different part of the stroke, due to it being impossible to get the coils adjusted to give the same natural period. However, engines by this time were of large cubicle capacity, and a slight loss of power, due to inaccurate timeing, did not signify much and, besides, if the mixture was uncertain, a shower of sparks usually managed to ignite it, and so starting was easy. Accumulator construction had then made some progress, but they were always things to be treated with great care, and the trouble of constantly getting them recharged, along with a little treachery on their part, still caused much trouble and annoyance.

Low-Tension Magneto.—Many firms fitted low-tension ignition about this time, it having been discovered, that a simple winding on a shuttle

armature, revolving between the poles of permanent magnets, produced all the current necessary for the production of a low-tension spark. As shown in Fig. 4, each cylinder was fitted with a mechanically worked arm to break the circuit inside the combustion chamber, the electrical circuit being of the simplest kind, and all the rest of the apparatus purely mechanical, even down to the method of advancing and retarding the spark.

The Mercédes firm made perhaps the most successful ignition of this type, and their engines, although of large size, started easily and with certainty, and if anything went wrong the fault was soon located. This ignition suffered from two drawbacks, the first being the difficulty of making a gastight joint in the combustion head, for the rocking arm to work in, and the second the difficulty of adjusting each cylinder to fire at the same point in the stroke. The first was overcome with a certain amount of success, but the second was always there, and although the makers, later, adapted a different system, incorporating a magnetic plug, it went down before the onslaught of the high-tension magneto. The makers of trembler coil ignition outfits also tried to improve the accuracy of the timing, by fitting one coil and a high-tension distributor, or by fitting a master vibrator, but this also found its way to the background, due perhaps to the bad mechanical design of contact makers.

High-Tension Magneto.—The truth about the matter was, that when an owner used a car fitted with a high-tension magneto (see Fig. 5), or, better still, fitted one to his existing car, the difference in performance due to an accurately timed spark synchronous in all cylinders, was so great that he everlastingly became a travelling advertisement for the high-tension magneto maker. It was self-contained, not straggling all over the car; it was reliable; the spark was always there, without constant battery charging; and as the battery

Comparison.—If we take a plain coil and connect it up to a battery with an ammeter and switch in the circuit, it is found that on closing the switch, the current I_B, in the primary, takes some little time to rise to its full value, due to the self-inductive effect of the coils. As indicated by the graph, Fig. 7. If at the end of this time the circuit is suddenly interrupted, the maximum spark obtainable at the secondary will be produced.

Now this is precisely what happens when an engine runs slowly, with the modern coil ignition,

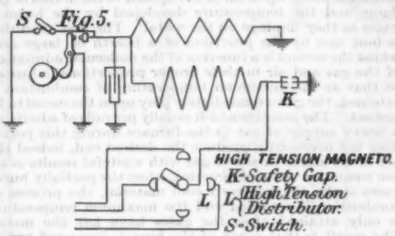


Fig. 5.

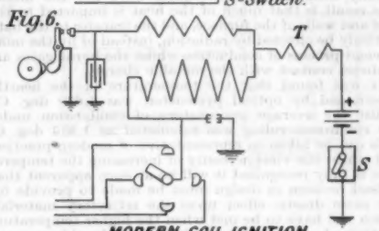


Fig. 6. MODERN COIL IGNITION.

S-Switch which automatically opens the circuit should the Engine stop with the Contacts closed. T-Ballast Coil, usually of Iron Wire to prevent I_B assuming a dangerous value.

(7162.D.)

of propagation of the explosion; apart from this the modern coil offers minor advantages such as an unlimited arc of firing position without influencing the quality of the spark.

With regard to the effect of the spark intensity upon the rapidity of flame propagation, a great deal of misconception is extant.

In the early days of the automobile, when bad carburation and scavenging, produced patchy and stratified charges, it was soon discovered that a poor spark was by no means certain of starting ignition in a weak mixture, and that a good, or what was then termed a "flaming," spark, rendered the operation much more certain. This, and the increased power output of multi-cylinder engines, due to the accurate synchronisation of firing provided by the magneto, led many to the erroneous conclusion that spark intensity greatly influenced flame propagation, it being, of course, well known that the magneto gave a spark of the "flaming" variety.

Modern experience has shown, however, that the effect of the spark on the power developed by engines is negligible, and that when, in the case of high speeds or large cylinders, the speed of the explosion wave is too low for the design, two-point ignition must be resorted to.

The above simply resolves itself into the fact that spark intensity above a certain point appears to be unnecessary and that the falling off in this direction, in the case of the modern coil, is of no material consequence.

It would therefore seem evident that the choice of an ignition apparatus for the modern automobile is simply governed by commercial considerations such as neatness, cost, and ease of fitting. It should not be forgotten, however, that the coil spark is at its maximum at slow speeds, which greatly enhances its value for starting and slow-running purposes. On the score of reliability

Fig. 7. CURVE SHOWING THE RATE OF GROWTH OF I_B WITH MODERN COIL IGNITION.

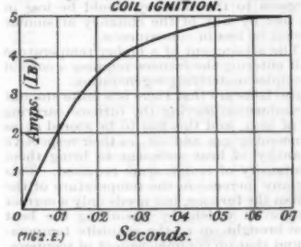


Fig. 8. CURVE SHOWING THE INFLUENCE OF ENGINE SPEED ON THE VALUE OF I_B WITH MODERN COIL IGNITION.

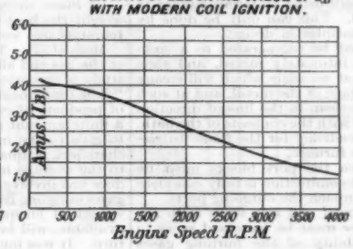


Fig. 9. CURVE SHOWING THE RISE OF E.M.F. WITH THE SPEED IN THE CASE OF A MAGNETO WHICH CAUSES THE SPARK TO INCREASE IN INTENSITY UP TO A POINT BY PRESERVING THE VALUE OF I_B.

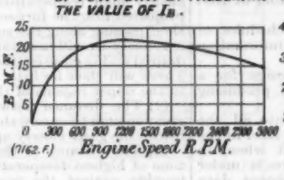
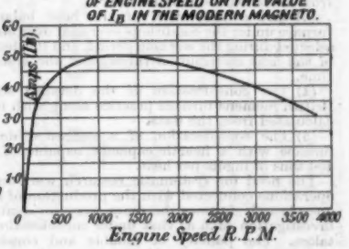


Fig. 10. CURVE SHOWING THE INFLUENCE OF ENGINE SPEED ON THE VALUE OF I_B IN THE MODERN MAGNETO.



ignition was retained, for starting purposes, he could show you that it made 10 miles an hour difference in speed. It is therefore not surprising that when engines were constructed small enough to swing, that coils were dispensed with, and also that when there is some talk of displacing the magneto by a coil, that certain people are ready to condemn the change as foolish.

Modern Coil Ignition.—Now the shortcomings of the old plain coil ignition have been explained at length, and it will be seen that they resolve themselves into what may be termed, battery trouble, and it will also be understood that had a modern battery been provided, kept charged by a dynamo on the car; and a thermostat, which would open the switch should it be accidently left closed with the engine standing; along with a ballast coil, to prevent a rush of current through the primary winding; nine parts of the trouble would have disappeared.

If we now add to this a properly-designed and constructed make and break and a high-tension distributor (as shown in Fig. 6), we find that we have the modern coil ignition, which is used so extensively on American productions. If this is now compared in diagram form with the high-tension magneto they will be found to be practically identical, and when the action in operation is considered they are found to be similarly alike, with the exception of the variation in intensity of spark, which is not the same for both over the speed range; an explanation as to why this occurs being as follows:—

i.e., we get the best spark. If the engine is now accelerated to a good speed it will be seen that the rise of the primary current value I_B, is considerably interfered with, when the engine runs at such a speed that the period of make of the contact maker is less than the time taken for I_B to rise to its full value.

In practice this value is in the region of 4·15 amperes at 300 r.p.m., and 1·75 amperes at 3,000 r.p.m., as shown in Fig. 8, the spark being correspondingly decreased in intensity, due to the secondary energy being fully dependent on I_B. Now in the case of the high-tension magneto, precisely the same conditions arise, but there is an important factor, which compensates for the shorter duration of make at high speeds, and that is, that the increase of speed of rotation of the armature increases the voltage of the current I_B (see Fig. 9), and thus compensates very materially for the lack of time during which the primary circuit is made, and causing I_B to rise at a greater rate as shown in Fig. 10.

It is therefore found that at the higher speeds, the intensity of the spark at the plug, in the case of the magneto, is well preserved.

It will have been gathered from the foregoing, that ignition history has now reached the stage where it is necessary to choose between the magneto and the coil, and that the only point capable of influencing the choice, from an efficiency point of view, is whether we need a spark of high intensity over the whole speed range, or in other words, what effect has the quality of the spark on the rate

there is nothing to choose, as a dependable current supply for the coil, has now been settled by the provision of a well-constructed accumulator kept charged by a dynamo on the car.

It may happen that in the future, designers may seek greater efficiencies in the direction of higher speeds, weaker mixtures, and higher compressions, in which case the falling-off of spark intensity with speed, in the case of the coil, may be deemed a disadvantage. This can be remedied, however, by incorporating, say, a centrifugal device to increase I_B in proportion to the speed, as occurs automatically in the case of the magneto. A device of this nature would increase the cost appreciably, but it is possible to incorporate the advantage by electrical means at very little extra expense.

The above is a brief *resumé* of the ignition problem as it stands to-day and it will be seen that, neglecting the unlimited advance and easier starting properties offered by the coil, the rival claims are somewhat equal; it may be, however, that in the future these will be the deciding factors.

BRITISH SIEMENS FURNACE PRACTICE.*

By FRED. CLEMENTS, M.Inst.C.E., M.I.MechE. (Rotherham).

AT the annual meeting of the Institute in 1920 the author had the privilege of reading a paper entitled

* Abstract of paper read before the Iron and Steel Institute, on May 4, 1922. The paper was accompanied by a number of sheets of diagrams and tabulated data which lack of space precludes us from reproducing.

"British Blast-Furnace Practice," and it was his intention at that time to follow this up with a similar investigation into Siemens Furnace practice as soon as opportunity permitted. He makes no apology for reverting to this very important subject, despite the fact that many new Siemens furnace installations have been put in during the last few years, for, whilst an examination of these shows a growing appreciation of the need of better mechanical detail in furnace construction, they follow well-established precedents as far as furnace proportions are concerned, and do not show any material advance in thermal efficiency over what has been obtained in the older plants. It is therefore towards the object of formulating some of the underlying principles which govern the design of regenerative furnaces, deduced from data obtained from good modern practice and by thorough analysis of the work done in the 60-ton furnaces at the Park Gate Works, that this paper is directed.

Arrangements were made to carry out tests at Park Gate, and for this purpose "K" furnace was selected, as it had recently been put into service again after complete repairs to body and chequers. Thermo-couple pyrometers were installed at all points where necessary and wired to a central indicating station. Special tubes were inserted and equipped with fittings so that gas samples could be taken easily. Manometers were also attached so that they could remain undisturbed during the period of the test. A mild steel box was built over the air reverse valves, and all the air passing into the furnace through the valves was caused to enter the box through a mild steel pipe into which was inserted a Pitot tube. The Pitot tube, together with the curved tube rate of flow indicator, were supplied by Messrs. George Kent, Limited, of Luton, and were guaranteed to give readings accurate to 0·5 per cent. This instrument was found to be in every way very satisfactory. The time was noted at which each hopper of coal was charged into one or other of the three producers which are isolated to provide the gas for the furnace, and as this occurred on each producer at intervals of about 15 minutes and the weight of coal was accurately known, it formed a convenient way of estimating the rate of fuel consumption. A testing staff was organised and divided into shifts, thus enabling the observations to be taken continuously over three heats. The heat which showed the most consistent set of data was selected for analysis. It may be stated here that it is not proposed to deal with the chemical side of steel manufacture except in so far as may be necessary to make clear any points which may bear on the main purpose of investigating the Siemens furnace as a thermal machine.

The synopsis of the paper is as follows :—

(1) The consideration of the balance of the chemical operations in the furnace hearth during heat K 3845.

(2) The consideration of the heat balance deduced from the chemical balance in (1).

(3) The consideration of the heat balance of the furnace under the conditions averaged over one half-hour selected during the working period, and the determination of the heat distribution throughout the system at that time.

(4) The consideration of the detailed schedules of British Siemens furnace practice along with information calculated from the data.

(5) The consideration of a suggested design for a furnace with a hearth capacity capable of producing 100 tons of ingots per heat.

The need for systematic research work into all the operations connected with the production of steel in the open-hearth furnace becomes very evident when an investigation such as that under consideration is undertaken. The paucity of reliable and consistent data renders the task of elucidating the results very arduous, and a combined effort ought to be made by steel-makers to systematise investigations. The full advantage could then be derived from the work done and the repetition of any unnecessary work avoided, so that the maximum result in progress could be looked for. This desirable end can only be attained by the united effort and support of steel manufacturers, as it is far too great a task for any one man, or indeed any one firm, to carry out. It is only by such effort that the improvement in economy of manufacture which is urgently necessary can be achieved.

The chemical balance-sheet showed one striking feature, viz., the considerable elimination of carbon, silicon, phosphorus and manganese which takes place during the melting period.

As for the heat balance, there are two facts which deserve special remark :—

(1) The thermal benefit of charging hot mixer metal, as distinct from the undoubted chemical advantage, becomes very apparent as the metal brings in $19·2 \times 10^4$ C.H.U., which is 40·5 per cent. on the total shown, and it can be taken that a larger proportion of heat than this would be required to melt it were the metal charged cold. On the other hand, the fuel used in keeping the metal hot in the mixer must be accounted for in comparative results. The consideration of the influence of the metal mixer is, however, outside the scope of this paper.

(2) The overall thermal efficiency amounts to only 16·98 per cent. and, in view of the considerable heat loss which this indicates, it becomes of great importance to investigate the heat distribution throughout the furnace installation and to examine whether any means of prevention or recovery can be adopted.

The losses naturally fall into four categories :—

(A) Radiation from the bath and port ends (44·2 per cent.).

(B) Radiation from the regenerators (15·5 per cent.).

(C) Radiation from flues (4·1 per cent.).

(D) Heat lost with the gases to the chimney (36·2 per cent.).

These categories are dealt with in sequence.

Category A.—The heavy radiation loss which takes place from the furnace body is entirely dependent upon :

(A1) The temperature ruling in the bath.

(A2) The area of the radiating surfaces.

(A3) The conductivity of the material used in the construction of the furnace.

Divisions (A1) and (A2) are in turn dependent upon the demands of the process, and it is necessary therefore to consider the conditions closely in order to arrive at a logical conclusion. Assuming that adequate mechanical facilities are available for charging the furnace quickly, the essential conditions are that the furnace should melt down the charge in the minimum time and that the subsequent operations should be as rapid as possible consistent with the complete thermal control of the conditions in the furnace.

Melting the Charge.—The rate at which the charge is melted depends upon the area exposed to the action of the flame and the temperature developed by the burning gases as they impinge on the metal. The first condition is best met by the provision of a hearth of large area whilst the second is a function of the molecular admixture of the gas and air in their proper proportions, adjusted so that as the maximum temperature of combustion is attained, the gases immediately play upon the metal to be melted. The practice which usually prevails of admitting a heavy supply of gas to the furnace during this period does not necessarily produce the desired end, indeed the use of an undue excess of gas with wasteful results is all too common. In such practice, when the partially burnt gases strike the relatively cool material, the process of combustion is retarded and the maximum temperature is only attained after the gases have left the metal. The result is that much of the heat is imparted to the roof and walls of the furnace, and the transfer to the bath can only be effected by radiation, instead of by the more efficient process of conduction whilst the burnt gases are in direct contact with the metallic charge.

It was found that the temperature in the hearth, determined by optical pyrometer, was 1,680 deg. C., whilst the average temperature of combustion under the conditions ruling was calculated as 1,803 deg. C. This can be taken as representative of modern practice, and whilst the vital necessity of increasing the temperature is fully recognised it will be at once apparent that radical revision in design must be made to provide for the more drastic effect upon the refractory materials which will have to be met when the higher temperature is attained. It must be admitted that the able research work which has been done on refractories during the last few years has enabled silica bricks to be improved to a standard of utility which is not likely to be surpassed by that class of material, and also that furnace practice of to-day is taking advantage of the bricks available well up to their capacity. At the moment there appears to be no practical alternative to the use of silica bricks for furnace linings, and the new conditions would have to be provided for whilst still using materials similar to those at present employed. This can only be done by adopting the following principles in design :—

(1) The gas and air must be regenerated to a sufficiently high temperature, intimately mixed, and then projected into the furnace at an angle which will ensure their passing along the surface of the metal, and at such a velocity as will maintain them in the line of direction desired and in close contact with the contents of the bath. There will then be little tendency for the flame to rise to the upper regions of the furnace.

(2) The distance between the port blocks must be great enough to ensure that combustion is fully complete before the gases closely approach the outgoing ports.

(3) The distance of the roof and side walls from the zone of highest temperature must be increased so as to provide against the possibility of the burning gases impinging on the refractory. The space between the stream of gases in combustion and the roof is considered to be occupied by an almost immobile mass of inert gas. The function of this gas is to reduce the heat effect on the refractories. The summation of the suggested alteration in design would leave the refractories working under conditions not more severe than those obtaining at present.

The heat contributed by the exothermic reactions involved in the removal of the elements is considerable. Now these reactions can be accelerated by an increase in the temperature ruling in the bath, and therefore the effect of raising the general temperature, as suggested, would be cumulative in so far that the quicker the elements are removed the greater will be the amount of heat generated per unit of time. There would follow therefore three important results :

(*a*) The slag would be maintained in a more fluid and workable condition.

(*b*) The time of working would be reduced.

(*c*) Greater advantage would be taken of the heat of chemical reaction.

The benefit of increasing the working temperature both in its effect during the working time and in the reduction of the time occupied in melting the charge, becomes an important factor in assisting economical manufacture.

It will be noted that the revisions in design involve an increase in the area of the radiating surfaces. The requirements, therefore, for more speedy furnace operation accentuate the already heavy loss by radiation from the bath and port ends, and it becomes imperative that consideration should be given to the best means for combating this serious wastage of heat. The most convenient method would be to use insulating bricks of the type which are now available. These are made to standard size and, if necessary, can be walled in with ordinary brickwork. The suggestion is made, however, that for the insulation of the rood the arch should be built as indicated on the 100-ton furnace design, Figs. 1 to 5, and the insulating bricks laid dry as shown. There is then a double protection, firstly by the air cavities formed, and secondly by the insulating bricks.

Category B.—There appears to be no reason why practically the whole of the 15 per cent. radiation loss from the regenerators should not be prevented. The temperatures inside the chambers are at present well within the working limit of the bricks, and it is not anticipated that any trouble would arise should it be necessary to raise the regeneration temperature of the gas and air. Consequently, the insertion of a 4½-in. insulating wall between the outer wall of red bricks and the interior firebrick lining should be all that is necessary to reduce the heat losses to a minimum.

Category C.—The temperature to be dealt with in the flues are relatively low, and therefore no difficulty arises in providing against the heat loss from this portion of the furnace. Either insulating bricks could be used or, if these be deemed too expensive, cavities filled with slag wool would suffice.

Category D.—The heat lost in the gases to the chimney, constituting as it does 36·2 per cent. of the total heat supplied to the furnace, is a difficult item to deal with briefly. Until relatively recent years this loss has been deemed necessary to the working of the furnace; but several firms have adopted waste-heat boilers with success. The consideration, from a financial point of view, of the capital cost, upkeep, and attention of such an installation as compared with the saving gained would be very valuable as a guide to future policy. Such an investigation is outside the scope of this paper, but it is hoped that some member who has had experience with this class of installation will undertake the work. Reference may be made to the very able paper by Mr. Mackenzie, presented to the Institute in September, 1918, which embodies the most complete technical data available on this subject. The ideal Siemens furnace, however, should be complete in itself, if considered as a thermal machine, and any extraneous device introduced for the recovery of heat can only be looked upon as a palliative. The logical sequel to this statement therefore is found in an examination of the design of the regenerator chambers.

Regenerators.—At this stage it may be desirable to emphasise again the need for a higher average temperature in the furnace hearth and examine how this may be attained. There appear to be two methods of achieving this end :

(1) By reducing the quantity of excess air admitted.

(2) By regenerating the gas and air to a higher final temperature.

Method (1) is desirable for several reasons :—

(*a*) The less the amount of excess air, the less the weight of air to be regenerated, and also the less the weight of products of combustion.

(*b*) If the volume of air admitted be carefully regulated the amount of oxidation by the furnace gases is also under better control.

(*c*) Since the gases to the chimney would be less in weight the heat lost by way of the chimney at similar temperatures would be less in consequence.

Method (2). The attainment of a higher temperature of the gas and air entering the furnace requires a careful study of the principles underlying regeneration.

The fundamental facts are that there is a finite amount of products of combustion leaving the furnace carrying a finite amount of heat, and this has to be stored so as to give to the incoming gas and air, in their respective chambers, a quantity of heat sufficient to bring them to the average intensity of temperature required. This does not involve any increase in the temperature of the gases outgoing from the furnace, but needs only a correct weight of chequerwork which, by absorbing the heat available, will be brought up to the requisite temperature. It was found that on commencement of recuperation, the temperature rises from 1,100 deg. C. to 1,400 deg. C. in the period of five minutes and during the remaining 25 minutes it rises up to 1,480 deg. C. Again when regeneration commenced half an hour earlier, the temperature of the incoming gas fell from 1,480 deg. C. to 1,200 deg. C. in 5 minutes, and in the further 25 minutes to 1,100 deg. C. The object therefore of regenerator design should be to arrange the proportion of the chequers so that the upper regions maintain their high level of temperature for a longer period. It follows that this can only occur if the temperature of the gases passing through the chequerwork be increased in the lower regions of the chamber, so that the upper layers have only to part with heat at a reduced rate sufficient to bring the passing gases up to the desired temperature. There are several factors involved in the provision of an efficient system of regeneration.

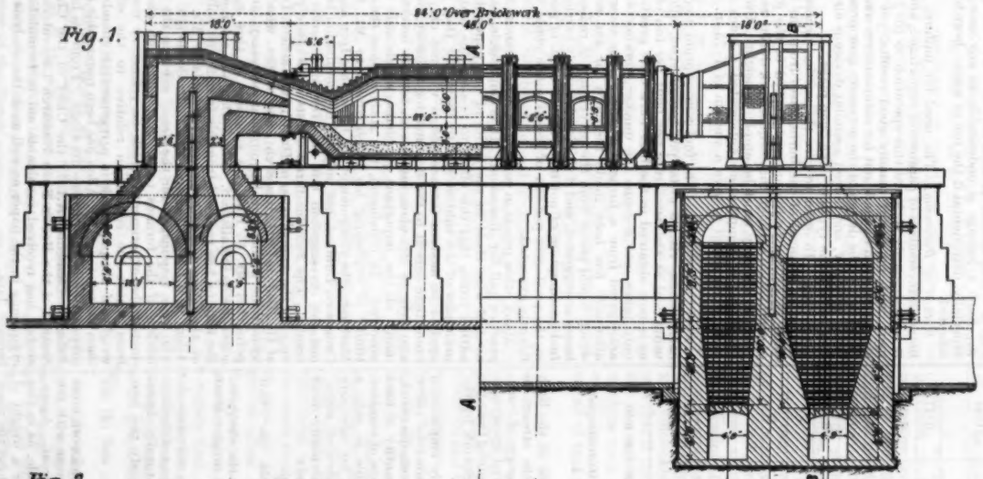
(1) The shape and dimensions of the chamber should be such that the gases during regeneration or recuperation are evenly distributed over the whole of the chequerwork, thus bringing all parts of it into service.

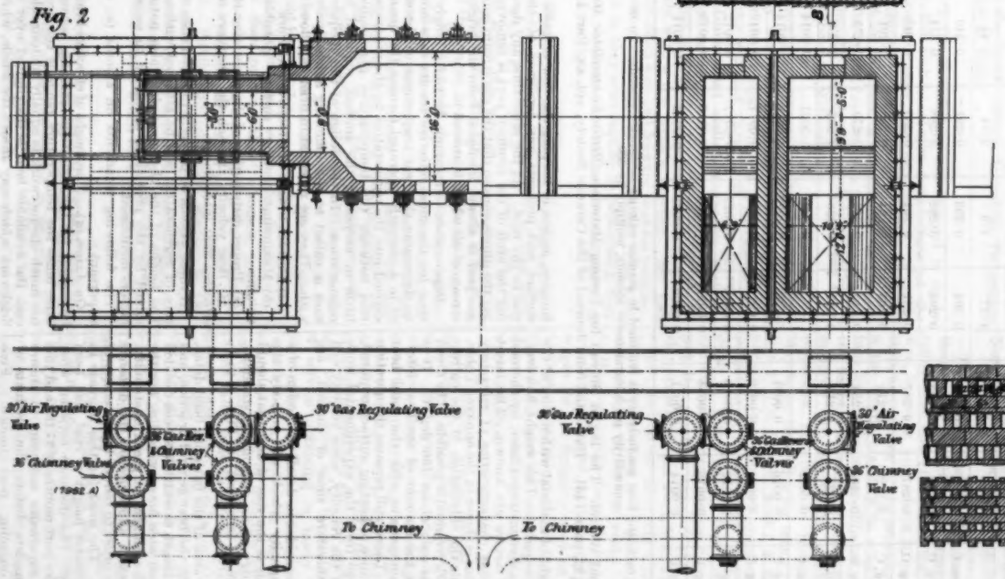
(2) The weight of suitable brickwork provided to form the chequering should be sufficient to ensure a store of heat ample for regeneration without a wide range of temperature.

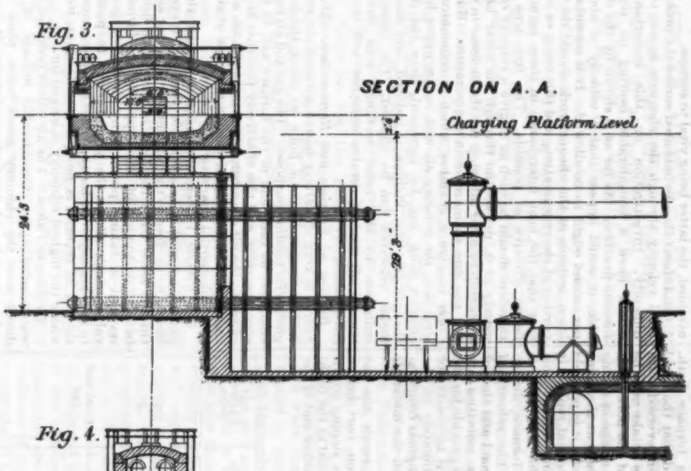
(3) The effective heating surface presented by the chequerwork must be ample to allow for a rapid heat exchange, and the arrangement of the chequers must be such that all the particles of the gases are brought into intimate contact with the hot surfaces. As the velocity of the gases is a factor in heat exchange it is important that this should be sufficiently high to give maximum results. A higher velocity also helps to keep the chequerwork free from dust deposit.

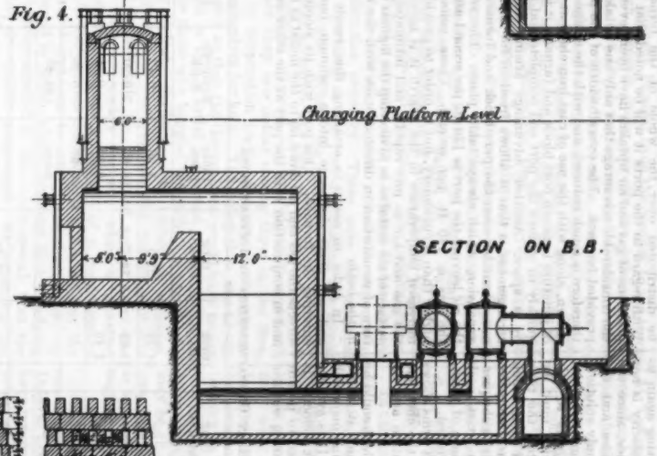
Dealing with these factors in sequence it is necessary to consider, in connection with No. 1, the natural direction of flow of the gases through the chequerwork, especially in regard to the tendency which always exists for the shortest route to be taken between inlet and exit. From this point of view it will be at once obvious that a regenerator chamber of the shallow horizontal type favours the short circuiting referred to, and consequently a chamber of considerable height in

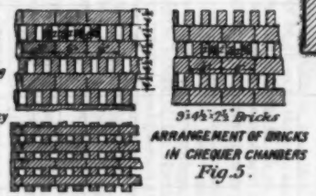
BRITISH SIEMENS MELTING FURNACE PRACTICE: DESIGN OF 100-TON FURNACE.











relation to cross-sectional area undoubtedly offers greater advantages. If all the circumstances of temperature and volume at various levels in the chequerwork be considered it is at once obvious that a chamber of rectangular section in elevation cannot provide the conditions required. Again it is essential that very close attention should be given to the even distribution of the gases as they leave the flue into the chequerwork, or *vice versâ* since all other effects are dependent upon this. With regard to No. 2 and No. 3 these are to some extent dependent on each other. The desirability of keeping the range of temperature difference in the regenerators as small as possible needs no emphasis, but the relation of heating surface to weight of chequers demands some comment. Arising out of research work done at Park Gate on the determination of the time-temperature gradient of a silica brick, it was found that on a basis of half-hourly reversals the only portion of the brick of real effective value is that within 1 inch of the surface. From this fact therefore we gather that in calculating the weight of the brickwork in a regenerator chamber only the effective value of the bricks should be allowed for. Deduced from the foregoing it is evident that bricks 2 in. thick would be the most economical from a heat exchange point of view, but considerations of stability in building may still influence the use of 3-in. bricks as is necessary at present.

The speed of the gases through the chequerwork is due to the pressure difference between the inlet and outlet points. During recuperation the suction of the chimney provides the motive force, but during regeneration the pressure difference in the air chamber is produced by the decreased density of the air due to increase in temperature during its passage through the chequerwork. High regenerators have an important bearing in this matter, since the increase in height tends to increase the pressure at the top of the chamber. This increase in pressure serves to propel the air through the port into the furnace and therefore governs the permissible velocity of projection. In the case of the gas, however, the pressure

from the producers renders it unnecessary to rely on the draught effect of the regenerators. Reverting again to the speed through the chequerwork the velocity is not that natural to the total pressure difference, since the influence of the friction between the gases and the brickwork has to be accounted for. The only solution, therefore appears to be to take average conditions and design the free passage through the chequers to suit these. Along with the question of velocity must be considered the correlated determining factor, the time of contact, since it is the combined effect of these which gives the ideal conditions of a gradual change of temperature to the gases in their passage through the chequerwork. Consequently, if these conditions exist each portion of the chequering does its fair share of work, and sudden variations of temperature are avoided.

A comparison of data supplied by different firms shows that where the speed of the gases through the chequers is the highest, the best results in recuperation and regeneration are obtained.

There are no data known to the author which could be applied to estimate the velocity above which it would not be economical to go, and this is a point on which experimental work is urgently necessary. It is evident that to ensure good results not only right velocity is necessary, but also sufficient heating surface to permit of the heat interchange. Behind this heating surface charging doors are provided, so that the charge can be distributed over the whole of the furnace bath. With regard to the ports it will be noted that the usual positions of gas and air uptakes have been reversed, with the considerable advantage that only one uptake need be provided for each. The overall width of the port block therefore is much reduced, and with the design of casing shown, along with the use of cast iron chills at the point of juncture between port block and furnace, it is possible quickly to remove the port end complete and replace it by a spare. Another advantage arising out of this arrangement is that it allows freedom for that relative movement between the port block and furnace, due to expansion, which always takes place. The velocity of the air leaving the port is 120 ft. per second and that of the gas is 140 ft. per second. These velocities are higher than is customary, but in order to provide for the increased temperature in the hearth it is necessary for the gas and air to mix rapidly and intimately on the surface of the metal so as to develop the highest temperature of combustion in direct contact with the materials in the bath.

In order to assist in attaining this result the gas and air ports discharge into a common port before entering the furnace. This port with its sloping crown directs the gas and air down on to the metal in the bath, and in conjunction with the port at the other end of the

TABLE GIVING HEAT CHARACTERISTICS OF REFRACTORIES.*

Material.		Grog Brick BC.	Grog Brick A.	Grog Brick B.	Grog Brick C.	Dinas Brick.	Magnesite Brick.	Carbon Brick.
Composition per cent.	Al_2O_3	40·0	30·42	24·34	25·0	1·56	0·17	Coke and tar.
	SiO_2	57·0	63·23	71·05	73·7	96·92	0·20	
	Fe_2O_3	—	1·98	2·46	—	0·62	0·31	
	CaO	—	0·5	—	—	0·97	0·35	
	MgO	—	0·25	—	—	trace	88·85	
	K_2O	—	3·45	—	—	—	—	
	Flux	—	—	—	1·34	—	—	
	Insol. in HCl	—	—	—	—	—	0·63	
Specific gravity	.. ..	1·88	1·8	1·77	1·9	2·04	2·35	1·27
Specific heat at	1,200 deg. C.	0·305	0·300	0·304	0·293	0·291	0·340	—
	1,000 deg. C.	0·298	0·295	0·295	0·292	0·288	0·324	0·412
	800 deg. C.	0·287	0·287	0·281	0·291	0·285	0·307	0·395
	600 deg. C.	0·272	0·273	0·263	0·284	0·282	0·291	0·377
	400 deg. C.	0·250	0·254	0·243	0·262	0·270	0·275	0·358
	200 deg. C.	0·225	0·216	0·217	0·223	0·237	0·258	0·312
Conductivity at	1,200 deg. C.	0·0072	—	—	0·0027	0·0021	0·0014	—
	1,000 deg. C.	0·0026	0·0021	—	0·0027	0·0018	0·0014	—
	800 deg. C.	0·0024	0·0019	0·0013	0·0027	0·0017	0·0013	—
	600 deg. C.	0·0022	0·0016	0·0012	0·0027	0·0017	0·0012	—
	500 deg. C.	0·0018	0·0014	0·0011	0·0024	0·0016	0·0015	—
	200 deg. C.	0·0014	0·0011	0·0009	0·0021	0·0013	0·0011	0·0012

Note.—In the above table the heat conductivity is reckoned in gramme-calories centimetre seconds. To convert into conductivity per kilogrammetre seconds, multiply by 360.

* By Heyn, Bauer and Wetzel. The Berlin Bureau for Testing Materials (*Berlin-Lichterfelder Mitteilungen*, 1914, vol. 32, page 145). Extracted from Journal of the Ceramic Society, vol. xx, Part I.

must be a sufficient weight of material within 1 in. of the surface to store the heat required. This weight, however, can be determined, as is demonstrated later, by thermal calculation, as all the factors are known. The latest determination of the heat characteristics of refractory bricks known to the author is shown in the annexed Table, and with these available the calculation of the correct weight of the chequerwork required is possible. The mean temperature variation is only about 100 deg. C. It is interesting to note that the amount of the heat interchanged is small in comparison with the total heat stored in the chequers. There still remains the question of the economical allowance of heating surface required, and this ought to emerge from the experimental work for the determination of the velocity, since velocity and heating surface, and therefore time of contact, are relative to each other.

It is now possible to consider in detail the design of a furnace of 100 tons capacity which will embody the principles outlined. This is the size of unit that should be adopted in this country as an economical standard. The suggested arrangement is shown in Figs. 1 to 5, on page 581.

Bath and Ports.—The area of the bath has been determined in accordance with the best general practice, and naturally the relation of length to width has been decided so that the bath is not too wide for easy fettling nor the distance between the arch springers too great for stability, even after making the extra allowance on the distance between the side walls in order to reduce the intensity of the radiant heat effect. The need for this increase in width, along with the greater height of roof, has been demonstrated previously. The distance between what may be called the effective port mouths is 37 ft., and this is deemed from other experience sufficient to ensure that combustion is complete before the products of combustion enter the outgoing port mouth. Five furnace, assists in keeping the flow of gases on the bath surface and prevents any tendency of the stream to rise to the roof. At the same time any danger of burning the arch of the common port is removed by arranging the dimensions so that the gas stream issuing from the gas port is always insulated from the brickwork by the stream of air which is around it.

Regenerators.—It cannot be too strongly emphasised that for the most effective results care must be taken to determine the best proportions of the chequerwork, as in a correctly operated furnace the quantity of heat carried into the regenerators by the products of combustion between the temperatures permissible is only a little in excess of the amount required for adequate regeneration. In the design of the chequerwork attention is called to the following axioms previously dealt with. They are repeated in brief as follows:

(*a*) Correct weight of effective brickwork.
(*b*) Maximum heating surface possible per unit volume.
(*c*) Proper distribution of the gases over the chequers.
(*d*) Best velocity through the chequers to give most effective heat interchange.

If these axioms be properly followed then the temperature of regeneration will be attained without difficulty. The height of the chequerwork is also naturally determined by the provisions necessary to satisfy the four factors mentioned.

The following comments on axioms (*a*) and (*d*) are important:

On Axiom (a).—The weight of effective brickwork must be correct for the conditions existing, because with too little mass the temperature range is too great. Again, too much chequerwork is equally undesirable, as in this case the available heat is distributed over a weight of brickwork which may absorb the whole, whilst the mass is so great as to prevent the requisite temperature being attained, the latter being vital to success.

On Axiom (d).—As indicated earlier the problem of the ideal velocity through the chequers is one of extreme difficulty. Investigation on this important subject would have a considerable bearing on regenerative furnace practice. As far as is shown by the data available, it would appear that a velocity of about 20 ft. per second ought to be allowed. It is essential that the lower sections of the chequerwork should do the major portion of the regeneration, and this being so it is necessary that the heat interchange in these regions should be as effective as possible. The free area arranged therefore should be such as to give a velocity of approximately 20 ft. per second through the lower half of the regenerators after allowing for the increase in volume of the gas due to increase in temperature. However, in order to give a chamber which is economical in construction, the velocity allowed in the upper half of the chequer work can be increased, since the density of the gas per unit volume is reduced, and consequently higher velocities can be allowed. The reason for the reduction in the cross sectional area towards the bottom of the regenerator chamber will therefore be self-evident.

Binding of Furnace and Regenerators.—The furnace hearth is very effectively bound without the need of the bottom longitudinal tie bolts by using the supporting girders for binding purposes. The gas and air regenerator chambers at each end of the furnace are, in the main, separate units, and this effectively prevents any leakage of gas to the air chamber, which is sometimes a source of trouble. The binding of the chambers is of simple but very substantial character.

Gas Reverse Valves.—In order to reduce the loss of gas on reversal it is advisable that the reverse valve should be as close to the regenerator chamber as possible. On the same basis the type of gas valve used should be such as to shut off the supply to the furnace whilst reversal is taking place. Any design of gas reverse valve which allows the producer-gas to pass directly to the chimney even for the space of a few seconds during the act of reversal is not permissible in an installation where the highest economy is looked for.

Air Reverse Valves.—The air valves provided are of the water-sealed type. Considerable leakage of cold air direct into the chimney gases takes place with the ordinary type of butterfly valve, or dry mushroom valve, unless special precautions are taken to prevent it. Such a leakage is undesirable in any case, but is especially detrimental if the use of waste heat boilers is adopted.

Method of Reversing.—The need for uniform periods between reversals is of paramount importance, and whilst it is customarily to leave this operation to the furnacemen, with no doubt usually good results, yet a very strong case can be made out for automatic reversal every half-hour. The design of the necessary gear presents no great difficulty, and indeed a similar device is already in service on some types of coke-oven plant.

Chimney.—In order to give the suction necessary for the quick removal of the burnt gases from the furnace bath as well as to maintain the speed of the products of combustion through the chequerwork during recuperation the chimney must be ample in height. Under the conditions of temperature anticipated a stack 200 ft. high is calculated to give a suction of 1·75 in. w.g. at the base.

Fuel Consumption.—The fuel consumption used in the calculations, viz., 3 cwts. per ton of steel, allows for using coal at the same rate per hour per ton of metal as is now obtained in the best Park Gate practice, and only takes into account the quicker working which is anticipated from a furnace of the design shown. No allowance has been made therefore for the economy which would result from the prevention of radiant heat losses as suggested, and if this is adequately carried out a fuel consumption of not more than 2 cwts. of good coal at the producers per ton of ingots made could be confidently expected.

Many other points in connection with Siemens furnace practice call for discussion. It is impossible, however, to deal with these in the limits of one paper, but the author trusts that this effort to re-state the underlying principles of the subject and to show how they can be applied in modern furnace design will not only be of immediate benefit to the steel-making industry, but may also help to stimulate interest in further investigating many of the important problems which still remain unsolved. In conclusion, the author takes the opportunity of expressing his indebtedness to Mr. Charles Markham, the Chairman of the Park Gate Iron and Steel Company, Limited, not only for his permission to carry out the investigation but also for his interest in its results. The Siemens furnace tests were made possible only by the co-operation of Dr. W. H. Hatfield, Director of the Brown-Firth Research Laboratories, who kindly loaned the pyrometrical equipment necessary, and also permitted Mr. C. Hall, his specialist in this work, to supervise its installation. The author also acknowledges the help he has received from his friends and colleagues of the Park Gate Company, particularly Mr. W. S. Allen, A.M.I.Mech.E., and Mr. T. P. Colclough, M.Sc., who were responsible for the detail work in the organisation of the furnace tests. Mr. Colclough also conducted the experimental work on refractory materials from which the conclusion relative to the effective weight of chequer work in a regenerator chamber has been abstracted. Mr. Allen has been responsible for the preparation of the furnace drawings. From his brother, John A. Clements, A.I.C., the Chief of the Chemical Section of the Brown-Firth Research Laboratories, the author has received invaluable aid in formulating the arguments in the paper as well as in the analysis of the furnace data.

THE LATE MR. ALEXANDER CLEGHORN.

MANY of our readers will learn with regret of the sudden death of Mr. Alexander Cleghorn, which took place at his residence, 14, Hatfield-drive, Kelvinside, Glasgow, on the 4th inst. He had throughout the whole of his professional life of over forty years served with Clyde firms, and did much to ensure the continued prestige of that district in marine engineering. He combined in a marked degree sound practical experience and high theoretical knowledge, and his well-balanced mind attuned itself readily to a recognition of equity in the relations of employer and worker, so that in the managerial posts which he successively filled he achieved full success. His last position was that of engineering manager and director at the Fairfield Works, from which he retired in October, 1920.

He was born on August 21, 1861, a son of the manse, his father being the Free Church minister at Leuchars, Fifeshire. He was educated at Madras College, St. Andrews, where he won the Tullis Gold Medal for mathematics and natural philosophy; at Edinburgh University, where he obtained honours in mathematics, chemistry and practical physics, and was a medallist in advanced dynamics and engineering; and at Glasgow University, where he was first and third prizeman in naval architecture. When eighteen years of age, he began his apprenticeship in engineering with Messrs. Robert Napier and Sons, Glasgow, with Dr. A. C. Kirk as his chief, and with them he continued for 15 years until 1894. Within this period Dr. Kirk did much work towards the development of the marine engine, notably in triple compounding, and Dr. Kirk's scientific mind and Mr. Cleghorn's enthusiasm reacted upon each other. Mr. Cleghorn in 1886 became chief assistant to the engineering manager. He was identified with the machinery of 2,500 i.h.p. for three gunboats, and with that of 12,600 i.h.p. for the battleship Sinope—all of the triple expansion type—for the Russian Navy. He was engaged also on the erection on board of the twin-screw machinery of 9,000 i.h.p. of H.M.S. Australia, the first British warship of any large size to be fitted with triple expansion engines. From 1887 to 1889 he was at Nicolaieff, erecting on board the machinery of the three gunboats, and he conducted all steam trials and completed Messrs. R. Napier and Sons' contract. In 1889, on returning to the Clyde he was appointed works manager, and he was then responsible for the construction of the machinery of the Royal Mail Steam Packet Company's steamers Magdalina, Thames and Clyde, each 7,000 i.h.p.; for the Orient Company steamship Ophir, 11,000 i.h.p.; for three of the Khedival Administration's fast steamers, each 3,600 i.h.p.; and for H.M.S. Gibraltar, 12,000 i.h.p.

In 1894 he entered the designing department of the Clydebank Engineering and Shipbuilding Company, and was associated with the machinery and arrangement of H.M. battleship Jupiter, 12,000 i.h.p., and H.M. cruiser Ariadne, 18,000 i.h.p.; of the Moskva, 15,500 i.h.p., for the Russian Volunteer Fleet, these vessels being fitted with boilers of the Belleville type. After being about five years at Clydebank he was appointed by Messrs. Barclay, Curle and Co., Limited, manager of their engineering department, and was responsible there for the machinery of varied types for a large number of steamers. Later he became a partner in the firm. In 1905 he entered the services of the Fairfield Shipbuilding and Engineering Company and continued there for 15 years, becoming at an early stage a director of the company. There is, however, no need to particularise as to the work done. He retired, as we have already said, in October, 1920, to enjoy the eventide of life, as his health had become somewhat impaired during the strenuous years of the war.

He became an associate member of the Institution of Civil Engineers in 1892, and was advanced to full membership in 1903. He was elected a member of the Institution of Naval Architects in 1899, and was for several years a member of the Council. He was also a member of the Council of the Institute of Metals. He served on the Council, ultimately becoming president, of the Institution of Engineers and Shipbuilders in Scotland. He had also been president of the Glasgow University Engineering Society, a governor of the Royal Technical College, Glasgow, and a member of the Technical Committee of Lloyds. In all of these offices he brought to bear judgment and experience, so that his services to organised engineering were of considerable value. He is survived by his widow and two sons.

INDUSTRIAL NOTES.

THE quarterly report of the General Federation of Trade Unions contains an "authorised trade union" description of the attempted revolution on the Rand. The important factors in the attempt were, it is stated, the existence of a violent communist element, and the inexperience of the Dutch workmen. The war, which started a sudden exodus to the various fronts of the British element, brought from the country to the towns a Dutch element quite new to the industrial conditions. The Dutch workers as a whole have nothing in common with the extremists, but they were too unsophisticated to judge whose counsel was the wisest, and so they became the victims of elements, both political and industrial, which soon led them astray. Through the Federation they enjoyed wages and conditions superior to anything they had ever been accustomed to, but the anti-Smuts political parties gave them no rest. The Nationalist Party preached Republicanism and hatred of the flag of Empire, the Labour Party preached hatred of the Chamber of Mines and nationalisation of mines, and the Communist Party revolution and Sovietism. The political propagandists had a common hate of General Smuts and the extreme industrial elements united in denouncing the Federation secretary. These were the principal factors operating at the period preceding the recent Rand strikes. When the trouble developed, an augmented executive was formed, the leaders of which were violently opposed to the Federation secretary, and when they saw defeat staring them in the face, turned in desperation to the elements more extreme than themselves for help. The policy then was to stir up the mob so that the Government would have to ask for terms or that martial law would be declared, and thus give those who bungled the strike the excuse of a military defeat. Strike leaders hinted at violence, and anyone who liked to take the risk of gaol was allowed to advocate it. It would appear from the report, that as always happens when a so-called progressive party calls in the aid of a revolutionary party, the latter takes control, and either reduces the whole social organism to misery and destitution, or, as happened in South Africa, produces such a rallying of the healthy-minded to the commonweal, that the insurgents are quickly suppressed. As instancing the violence of the extremist elements in this case, the report states that the leaders had given orders that the secretary of the South African Industrial Federation should be shot at sight.

Relief work for Nottingham unemployed is to be provided in the sinking of the foundations of the new super power station, the first section of which will be commenced in a few days. Over 1,000,000*l.* is to be spent on this part of the scheme, which will link up with Derby and Leicester in a joint undertaking and will eventually supply electricity to every town and village in the East Midlands.

We deal elsewhere with the Engineering Inquiry, so will merely note here the statement made by Mr. J. N. Bell for the General Workers' Federation, with reference to the frequent claim of the Amalgamated Engineering Union that skilled mechanics shall be alone employed on work which experience during the war showed that mere girls could learn to do effectively and efficiently with a few week's practice. Mr. Bell said that if the claim were put forward that his people—the General Workers—were to be excluded from such machine work as they were capable of performing, they would have to challenge that claim very definitely on behalf of their workpeople.

Mr. J. H. Thomas, in referring to the dispute at a meeting at Derby on the 7th inst. observed that there were people who said: "Bring everybody out, and that will soon settle this matter." The more people there were involved in a dispute the more difficult it would be and the longer, he said, it would take to reach a settlement. We may add, further, that we believe there is no instance on record of the policy criticised by Mr. Thomas, proving other than disastrous to the strikers. Every general strike has failed, for the obvious reason that if civil peace is maintained, the community can carry on all essential services, effectively, if at the outset, not too efficiently. On the other hand, if society were unable to protect the volunteers who came to its aid in a general strike, the result would be a revolution which the vast majority of men do not desire, and which has, in all cases, proved more disastrous to the "common people" than to anyone else. The true solution for industrial troubles is that neither party shall ask for more than a square deal. Public opinion always prevails in the end, and though it may be temporarily misled, will not long sanction unjust demands, whether made by Welsh pit men or by dock companies, as was instanced in the great dock strike which took place a generation ago.

In this connection, it is perfectly certain that the public would not approve of "peaceful picketing," as the term is too often interpreted in practice, but few of the daily papers venture to tell the truth in this matter. At Sheffield, it is reported that not merely have the men who have continued at work been threatened with violence, but their families also. At Coventry, too, it appears that there has been considerable violence. We are glad to note, however, that the Union officials have in several instances not merely disclaimed responsibility but have strongly deprecated the incidents. It used to be a maxim of our constitution that the law provided a legal remedy for every tort, but the Government of the day, after long opposing the Trade Disputes Act, on the ground that it traversed this maxim, finally yielded to threats of political opposition, and to save their party, ultimately swallowed their protests. As Horsea Biglow once remarked, "A Merciful Providence fashioned them holler: On purpose they might their principles swaller."

In Birmingham, men "locked out" have been dealt with by the Guardians as if unemployed, but the position has been altered by the opening of the shops to all men who are prepared to come to work. The law relating to the position in these cases is briefly as follows:—Relief at the cost of the Poor Rate cannot be legally granted to an able-bodied man who is physically fit to work and able to obtain work at wages sufficient to support himself and dependants. If such a man becomes so reduced by want as to be physically unable to work he may then be relieved by the Guardians, but this is subject to the liability to prosecution of the man for neglecting to maintain himself. Out-door relief may be given to the wife and dependants of a man who can, if he chooses to do so, obtain work, but if relief is so granted, the man will be liable to prosecution for neglect to maintain his wife and dependants.

Declaring that they cannot afford to pay more out of their small earnings, the members of the New Delaval Lodge of the Northumberland Miners' Union have notified headquarters that in future they will only contribute 1*s.* per head per fortnight, which is only half the fixed subscription. If neighbouring collieries follow suit, a crisis will be precipitated in both the Northumberland and Durham organisations.

The shipyard strike has been called off, although there were 46,306 votes against acceptance of the reductions, and 41,264 for acceptance. The total vote was, however, only about 30 per cent. of the membership, and in view of the provision of the rules requiring a two-thirds majority to continue a dispute entered into by the societies affiliated to the Federation, and the ballot vote which is taken not having the required majority, the negotiating committee instructed their respective members to resume work on Monday, May 8, on the following terms: An immediate reduction of 10*s.* 6*d.* per week; a second reduction of 3*s.* per week from the week commencing May 17; a third reduction of 3*s.* per week from the week commencing June 7. The stoppage began on March 29, so that it has extended over between five and six weeks. If we put the average wage of the skilled worker in the shipyards at 4*l.* per week, he has sacrificed nearly 24*l.* in wages, and on the other side of the balance-sheet, he has to set the deferring of 3*s.* of the reduction for one week and a further 3*s.* for four weeks. There has to be added to this loss in the domestic budget of the workers the substantial loss to the industry and to the workers in wages for the finishing work on several ships removed to Continental shipyards, so that they might sail at the fixed dates, and the necessary repair work required to other ships. It is possible that this loss amounts to some 500,000*l.*

The second annual report of the West Midland Industrial Council for the Electricity Supply Industry states that questions arose during the year as to whether, where specific working conditions prevailing in certain undertakings were more favourable to the employees than those embodied in the standard conditions, the previous conditions should prevail. The Council determined that the standard conditions taken as a whole were more favourable than the conditions of service obtaining in many parts of the district previously, and that such standard conditions must be regarded as a whole. It was held, therefore, that it would be wrong in principle for the employees to be entitled to select the best of such model conditions and at the same time to retain certain of the former conditions that were more favourable to them, subject to any specific anomalies being considered as such. It was strongly represented to the Council that it was necessary to make some modification of the standard working conditions in the case of small undertakings. The conditions of working obtaining in small undertakings of 1,000 kw. plant capacity, or less, are such that it was apparent to the Council that some of the standard conditions would be irksome and inequitable. This was recognised not only on behalf of the employers, but of the employees. Much attention has been given to this question, and as the result of negotiation with representatives of such undertakings, a modified set of working conditions was approved and has now been ratified by the National Council.

WATER-TUBE BOILER WITH UNDERFEED STOKER FOR SHIPBOARD.

FIG. 1.

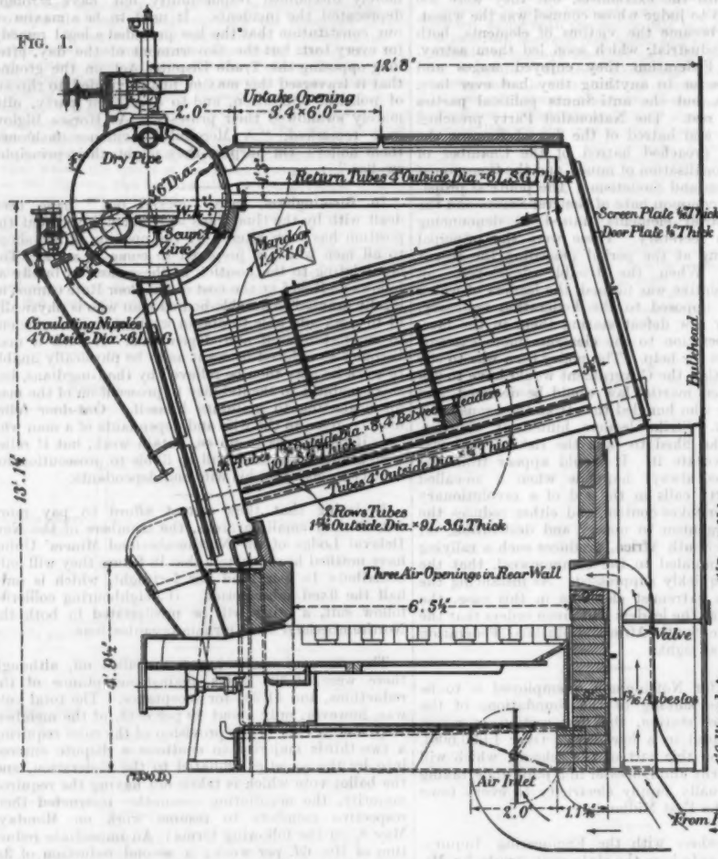
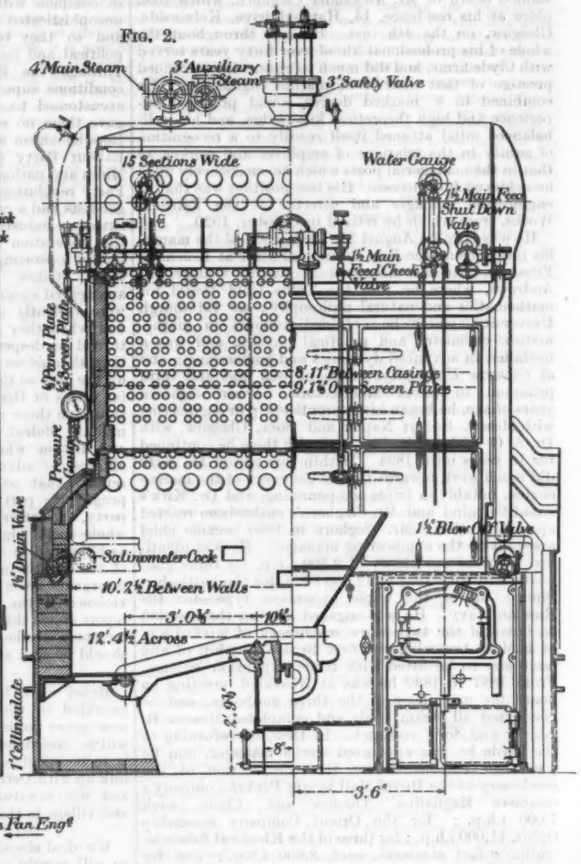


FIG. 2.



THE same advantages which have led to mechanical stoking becoming the standard practice for large boiler installations on land, are, of course, operative in the case of marine installations, but for various reasons little progress has been made with mechanical stoking at sea. This is no doubt partly due to the prevalence of the internally-fired Scotch boiler, whose furnaces are too small to permit of the introduction of mechanism to dispose automatically of the ashes and clinker from the fires. With the water-tube boiler this difficulty disappears, and from the engineering point of view mechanical stoking becomes as easy on a steamer as in a power station. The instability of the vessel need not necessarily introduce any problems more difficult than have already been solved in connection with all the rest of the machinery on board ship, and provided that the mechanical stoker is of such a type that hand-firing may be resorted to in case of possible trouble, there seems no reason to doubt that ample security may be obtained with probably greater efficiency and less labour cost. If mechanical stoking ever does become general at sea—and it may be noted that the objections raised to it by marine engineers are remarkably similar to those put forward by power station engineers when first it was brought to their notice—it will do so chiefly on the grounds of labour-saving. Good hand-firemen are becoming scarcer every day, as oil-fired boilers and internal-combustion engines both decrease the area of the training ground and bring into prominence, by comparison, the arduous nature of a fireman's duties at sea. A higher standard of boiler efficiency is now aimed at, and with a decreasing supply of skilled firemen, mechanical firing under expert supervision affords a solution which is worth consideration.

The Koninklijke Paketvaart Maatschappij, of Amsterdam, a Dutch steamship company, have put into service a small steamer, the Bintoehan, for trading in the Dutch East Indies, and the vessel is interesting from the fact that steam is raised by a water-tube boiler of the Babcock and Wilcox marine type fitted with an underfeed mechanical stoker. By the courtesy of Mr. W. J. Muller, the superintendent engineer of the owners, we were given the opportunity of travelling on the Bintoehan from Hull to Newcastle, at which latter port she took on board a cargo of firebricks preparatory to sailing for the East. The vessel is 230 ft. long by 38 ft. beam, with a tonnage of 1,250 tons. She was built by the N.V. Werf Hubertina V/H W. H. Jacobs Scheepswerf Machinefabrick, of Haarlem, Holland, who also constructed the engine, which is of the triple-expansion type, with cylinders 15½ in., 25½ in. and 43 in. diameter by 27 in. stroke, developing 650 i.h.p. at 100 r.p.m. The boiler was built by the Werkspoor Company, of Amsterdam, to Messrs. Babcock and Wilcox's designs, the latter firm also supplying certain of the detail parts, and the stoker by the Underfeed Stoker Company, Limited, of Coventry House, South-place, E.C. The boiler and mechanical stoker are illustrated in Figs. 1 and 2, annexed.

The heating surface of the boiler is 2,175 sq. ft., and the working pressure is 180 lb. per square inch. The general arrangement of the whole plant and the overall dimensions are shown in the illustration. The grate surface measures 6 ft. 5½ in. from front to back and 10 ft. 2½ in. between side walls, so that the area, including that of the surface of the dumping plates works out to 65·9 sq. ft. For clearer details of the stoker mechanism, the reader should refer to Figs. 3 to 6, on page 585. These illustrations relate to a grate of the ordinary land type, but the mechanism of the marine stoker is exactly the same, the only changes being in connection with the air chambers.

Underneath the external part of the stoker will be seen a horizontal steam cylinder, which actuates the mechanism. The piston rod gives a reciprocating motion to a long cast-iron plate lying on the bottom of the trough between the two sets of fire-bars, and at the same time moves, a pusher-block immediately beneath the bottom of the hopper, to and fro'. When the piston moves forward, the coal which has descended from the hopper is pushed forward by the pusher, and that which lies in the trough is carried bodily forward on the plate. When the piston returns, the coal lying on the moving plate cannot return with it, as it is caught by the sloping plate at the front end of the trough and the fixed plate on which the pusher slides. The sloping abutments bolted to the sliding plate therefore pass under the coal and lift some of it up out of the trough and on to the ends of the fire-bars. As the grate works, the coal passes slowly down over the sloping surface of the fire-bars, its motion being assisted by a slight reciprocating motion which is given to each alternate pair of bars.

The moving fire-bars are each provided with a pair of lugs on the underside, which engage with a projecting feather on a shaft on each side of the grate, passing longitudinally under the grate. The ends of these shafts, which project at the front of the grate, are formed each with a pair of spiral feathers. These feathers are embraced by corresponding nuts which are moved longitudinally to and fro' as the main piston reciprocates. Their motion causes the shafts to have a rocking motion, which, of course, gives the required motion to the fire-bars. The latter move to and fro' about 1 in.

The fuel as it descends slowly over the sloping fire-bars is burnt, and the slag, ashes and clinker are delivered on to the horizontal dumping plates at each side of the furnace. These plates can be swung downwards on a hinge-bar which runs along under the lower end of the fire-bars and is operated by a lever from the boiler front. Thus the refuse is dumped into the space below, whence, in the marine setting, it is raked forward on to the firing floor and disposed of in the usual way. All the moving parts of the stoker operate in unison with the motion of the piston in the steam operating cylinder, and as this can be regulated from 20 to 900 strokes per hour, it will be seen that the rate at which coal is supplied to the furnace can be varied within extremely wide limits. Every stroke of the piston carries into the furnace about 6 lb. of coal.

The air from the forced draught fan on the S.S. Bintoehan is delivered partly above and partly below the fire, by the ducts shown in Figs. 1 and 2. The three openings in the rear wall admit air above the fire, the quantity being regulated by the valve shown. The greater part of the air, however, passes through another controlling valve, into the space underneath the central feeding trough of the furnace. Its only way of escape from this compartment is by flowing through the centre of the fire-bars, which are made hollow for the purpose. The photograph reproduced in Fig. 7 shows the construction of the fixed and moving fire-bars, respectively, and Fig. 3 shows a section through one of the bars. From the latter

DETAILS OF UNDERFEED STOKER.

CONSTRUCTED BY THE UNDERFEED STOKER COMPANY, LIMITED, LONDON.

Fig. 3.

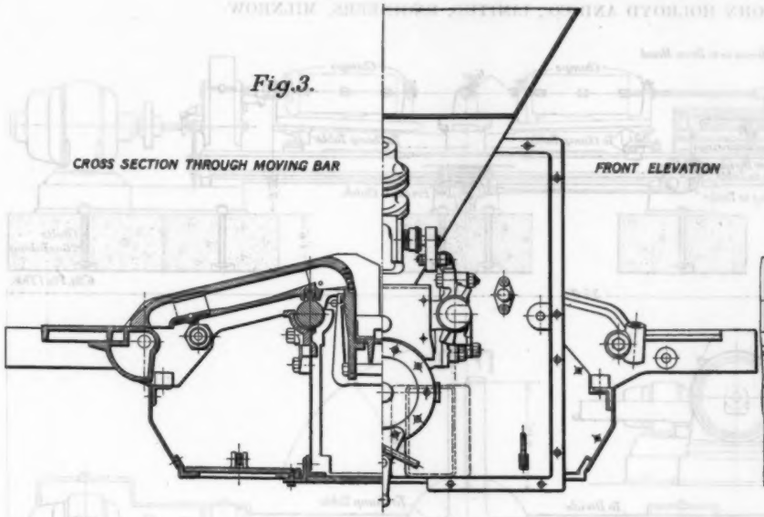


Fig. 4.

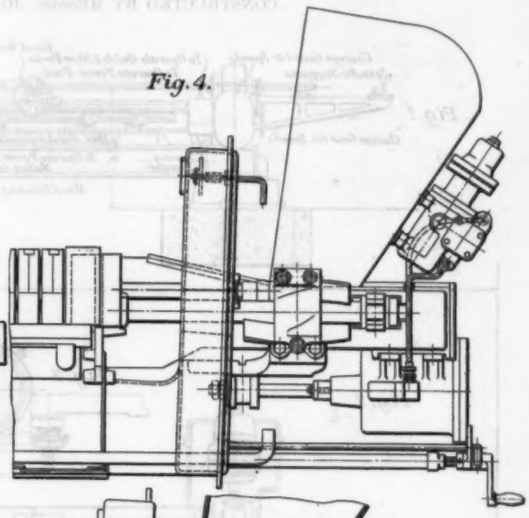
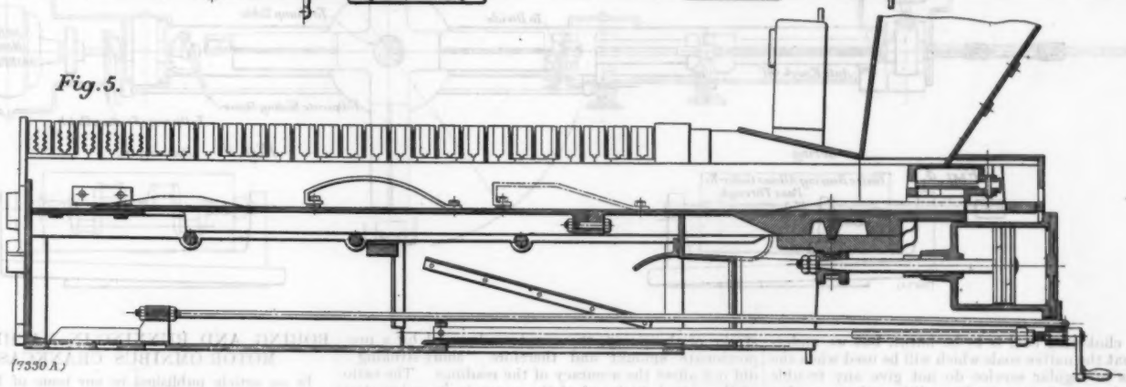
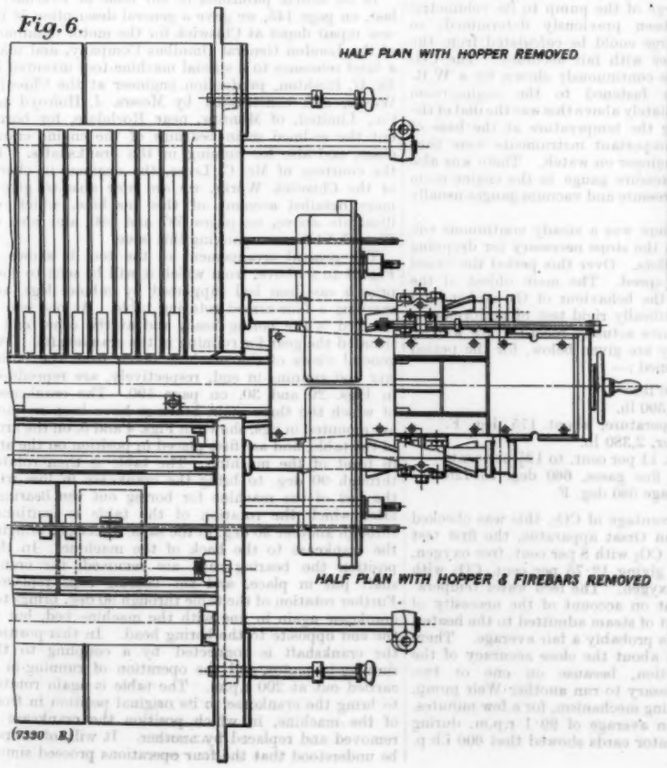


Fig. 5.



(7330 A.)

Fig. 6.



(7330 B.)

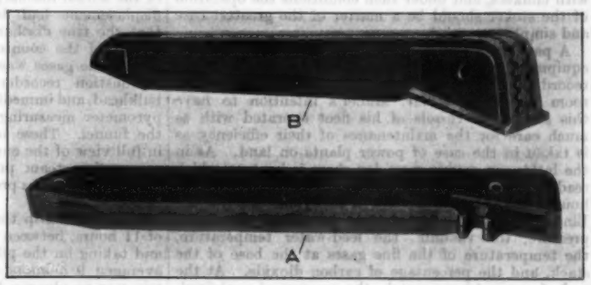


FIG. 7.

illustration it will be seen that some of the air can escape through ports in the inner end of the fire-bars, and pass through the fuel which is leaving the trough. Most of the air, however, traverses the bars from end to end, cooling them in the process, and at the same time being itself raised to a temperature of 350 deg. to 400 deg. F. in its passage. At this temperature it descends into the hot air chambers underneath the bars and escapes upwards between the bars and through the burning fuel. It will be evident that opening the dumping doors to clean the fires does not permit the entrance of any air to the furnace, nor does it interfere with the draught.

The coal used on the trip of the Bintoehan to which we have referred was South Yorkshire hards containing a very large proportion of slack and dust. Its analysis was as follows :—

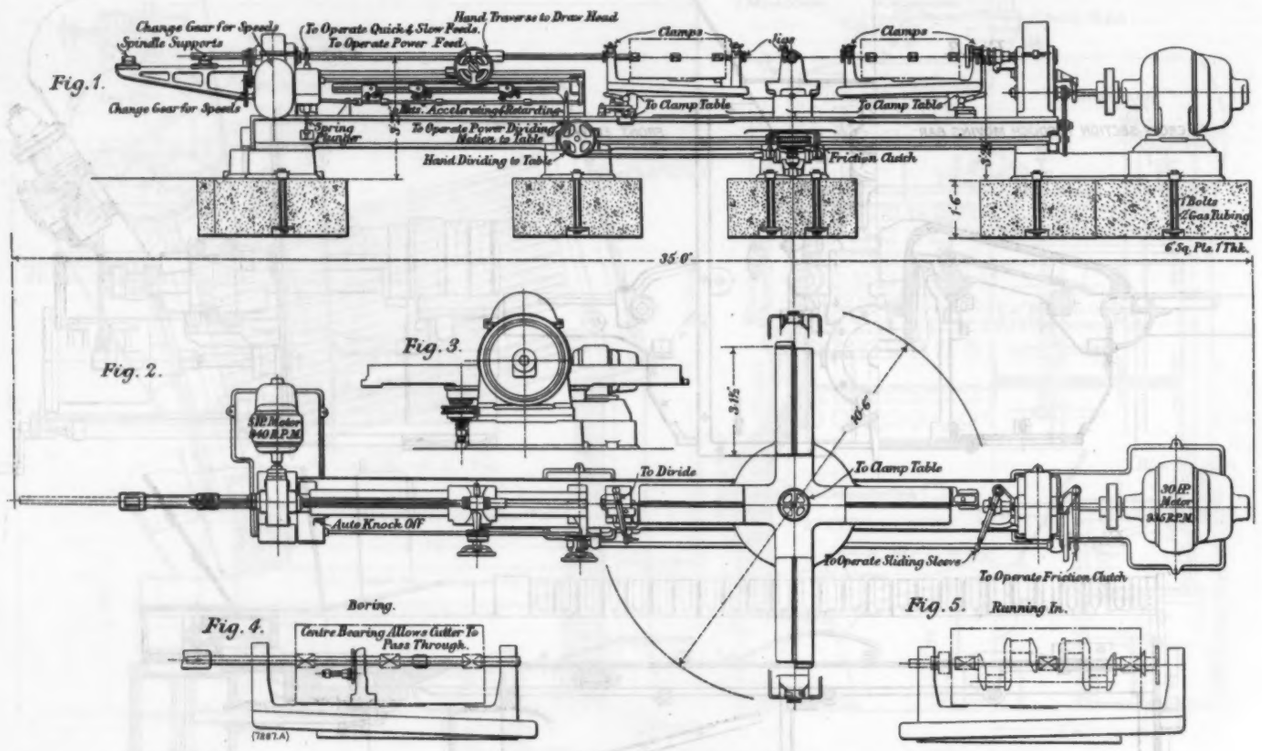
	Per Cent.
Ash	6·65
Moisture	7·34
Volatile matter	31·66
Fixed carbon	54·15

Net heating value, 12,400 B.Th.U. per pound.

The fineness of the coal rendered it by no means attractive from the point of view of mechanical stoking, but the underfeed stoker burned it without the least difficulty and the fire was always in an excellent condition. A considerable quantity of slag and clinker was formed, more indeed than one would have anticipated from the analysis of the coal, and at times it was somewhat difficult to dispose of this by means of the dumping doors. The latter might possibly be made somewhat larger with advantage,

BORING AND RUNNING-IN MACHINE FOR MOTOR-OMNIBUS ENGINE CRANKCASES.

CONSTRUCTED BY MESSRS. JOHN HOLROYD AND CO., LIMITED, ENGINEERS, MILNROW.



when a clinkering coal is to be burnt, but we understand that the native coals which will be used when the vessel is in regular service do not give any trouble with clinkers, and under such conditions the operation of the stoker should be a matter of the greatest ease and simplicity.

A particular feature of the vessel was the complete equipment of instruments, &c., for keeping a proper record of the performance of her boiler and engine-room plant. It is Mr. Muller's intention to have this and other vessels of his fleet operated with as much care for the maintenance of their efficiency as is taken in the case of power plants on land. As in the latter, an engine-room log sheet is kept on which readings of certain instruments are entered every hour, and others at the end of every watch. On the Bintoehan, the hourly records comprised the boiler pressure, the vacuum, the feed-water temperature, the temperature of the flue gases at the base of the stack, and the percentage of carbon dioxide. At the end of every 4-hour watch, the amount of coal fired, and of water pumped into the boilers was recorded, as well as the engine revolutions made during the watch. The engineers were also required to log hourly a figure showing the combined losses due to the temperature and composition of the flue gases, so that the importance of maintaining the best possible furnace conditions should be continually brought to their notice. This figure was obtained from a table which showed the calculated combined percentage loss due to any percentage of CO_2 and any flue gas temperature within the range of practical working. We were informed that the Dutch engineers took the greatest interest in the economical working of the plant, and that there was a great demand for jobs on the vessels which were equipped with apparatus to show the efficiency obtained.

The coal during the trip was measured by counting the number of skips used, the weight of a skip of coal being checked by a Salter balance. The feed-water was measured by an integrating mechanism worked from the crosshead of the Weir pump. The crosshead had attached to it a cord, the other end of which was wound round a spiral groove cut on the surface of a cylindrical drum. As the crosshead descended, the cord caused the drum to rotate against the action of a spring. The spindle of the drum drove a small counting gear. Thus no matter what the length of any stroke of the pump, the counter advanced by a proportionate amount and therefore "short-stroking" did not affect the accuracy of the readings. The ratio of the actual discharge of the pump to its volumetric displacement had been previously determined, so that the true discharge could be calculated from the figures of the counter with fair accuracy. The CO_2 in the flue gases was continuously shown by a W.R. combustion recorder fastened to the engine-room bulkhead, and immediately above this was the dial of the pyrometer measuring the temperature at the base of the funnel. These important instruments were thus in full view of the engineer on watch. There was also a recording steam pressure gauge in the engine-room besides the various pressure and vacuum gauges usually fitted.

During the trip there was a steady continuous run of 11 hours, between the stops necessary for dropping and taking on the pilots. Over this period the vessel averaged 9·5 knots speed. The main object of the trip was to observe the behaviour of the stoker, and not to make a scientifically rigid test of performance. Nevertheless the figures actually recorded are worthy of statement, so they are given below, for the period of 11 hours mentioned:—

Coal fired, 14,876 lb.
Feed water, 115,590 lb.
Feed-water temperature, about 175 deg. F.
Ashes and clinker, 2,380 lb.
CO_2 in flue gases, 11 per cent. to 12½ per cent.
Temperature of flue gases, 660 deg. to 720 deg. F. Average 680 deg. F.

As regards the percentage of CO_2, this was checked twice by means of an Orsat apparatus, the first test giving 11·5 per cent. CO_2 with 8 per cent. free oxygen, and the second test giving 12·75 per cent. CO_2 with 7·75 per cent. free oxygen. The feed water temperature varied somewhat on account of the necessity of regulating the amount of steam admitted to the heater, but the figure given is probably a fair average. There is also a little doubt about the close accuracy of the feed-water consumption, because on one or two occasions it was necessary to run another Weir pump, not fitted with recording mechanism, for a few minutes. The engine ran at an average of 99·1 r.p.m. during the period, and indicator cards showed that 600 i.h.p. was being developed.

BORING AND RUNNING-IN MACHINE FOR MOTOR-OMNIBUS CRANKCASES.

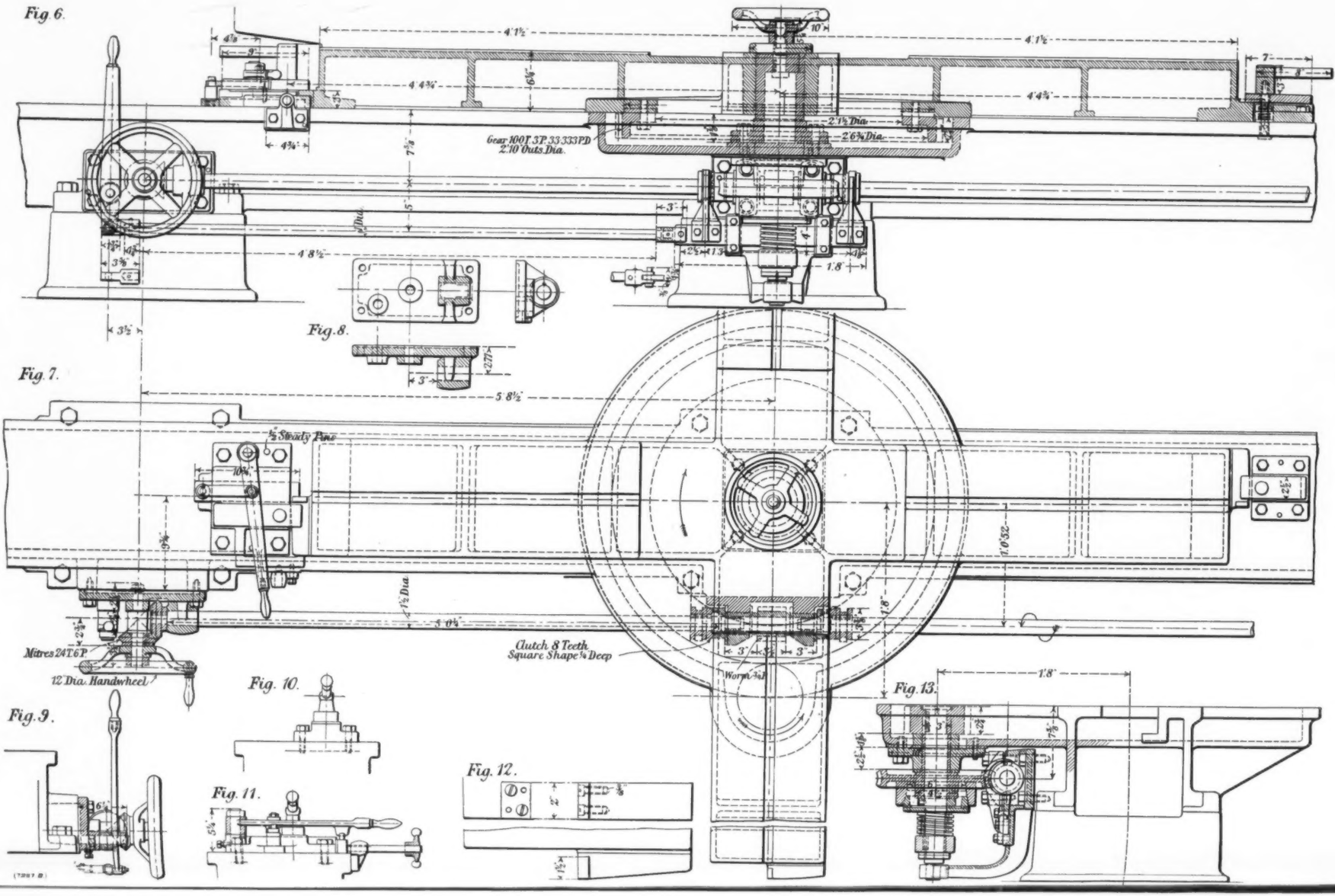
IN an article published in our issue of February 3 last, on page 145, we gave a general description of the new repair depot at Chiswick for the motor omnibuses of the London General Omnibus Company, and made a brief reference to a special machine-tool invented by Mr. G. Rushton, production engineer at the Chiswick Works, and constructed by Messrs. J. Holroyd and Co., Limited, of Milnrow, near Rochdale, for boring out the re-lined main bearings of the engine crankcases, and also for running in the crankshafts. By the courtesy of Mr. C. Leese, the engineer in charge of the Chiswick Works, we are now able to give a more detailed account of this machine, which we illustrate above, on pages 587 and 590, and also on Plate XXIV accompanying this issue.

The general arrangement of the tool is shown in Figs. 1 to 3 above, from which it will be seen to comprise a cast-iron bed supported by cabinet legs, and carrying a four-armed rotating table. At one end of the bed is the boring head, and at the other end is situated the gear for running in the crankshafts. Two general views of the machine taken from the boring end and running-in end, respectively, are reproduced in Figs. 29 and 30, on page 590. The crankcases, of which the three main bearings have been re-lined, are mounted in jigs, shown in Figs. 4 and 5, on the arms of the table, and are first placed in position on the arm in front of the machine. The table is then rotated through 90 deg. to bring the crankcase in line with the bed of the machine for boring out the bearings, after which the rotation of the table is continued through another 90 deg. in the same direction, bringing the crankcase to the back of the machine. In this position the bearing caps are removed, the crankshaft put in place, and the bearing caps replaced. Further rotation of the table through 90 deg. brings the crankcase again in line with the machine bed, but at the end opposite to the boring head. In this position the crankshaft is connected by a coupling to the running-in motor, and the operation of running-in is carried out at 200 r.p.m. The table is again rotated to bring the crankcase to its original position in front of the machine, in which position the crankcase is removed and replaced by another. It will, of course, be understood that the four operations proceed simul-

BORING AND RUNNING-IN MACHINE FOR MOTOR-OMNIBUS ENGINE CRANKCASES.

CONSTRUCTED BY MESSRS. JOHN HOLROYD AND CO., LIMITED, ENGINEERS, MILNROW.

(*For Description, see Page 586.*)



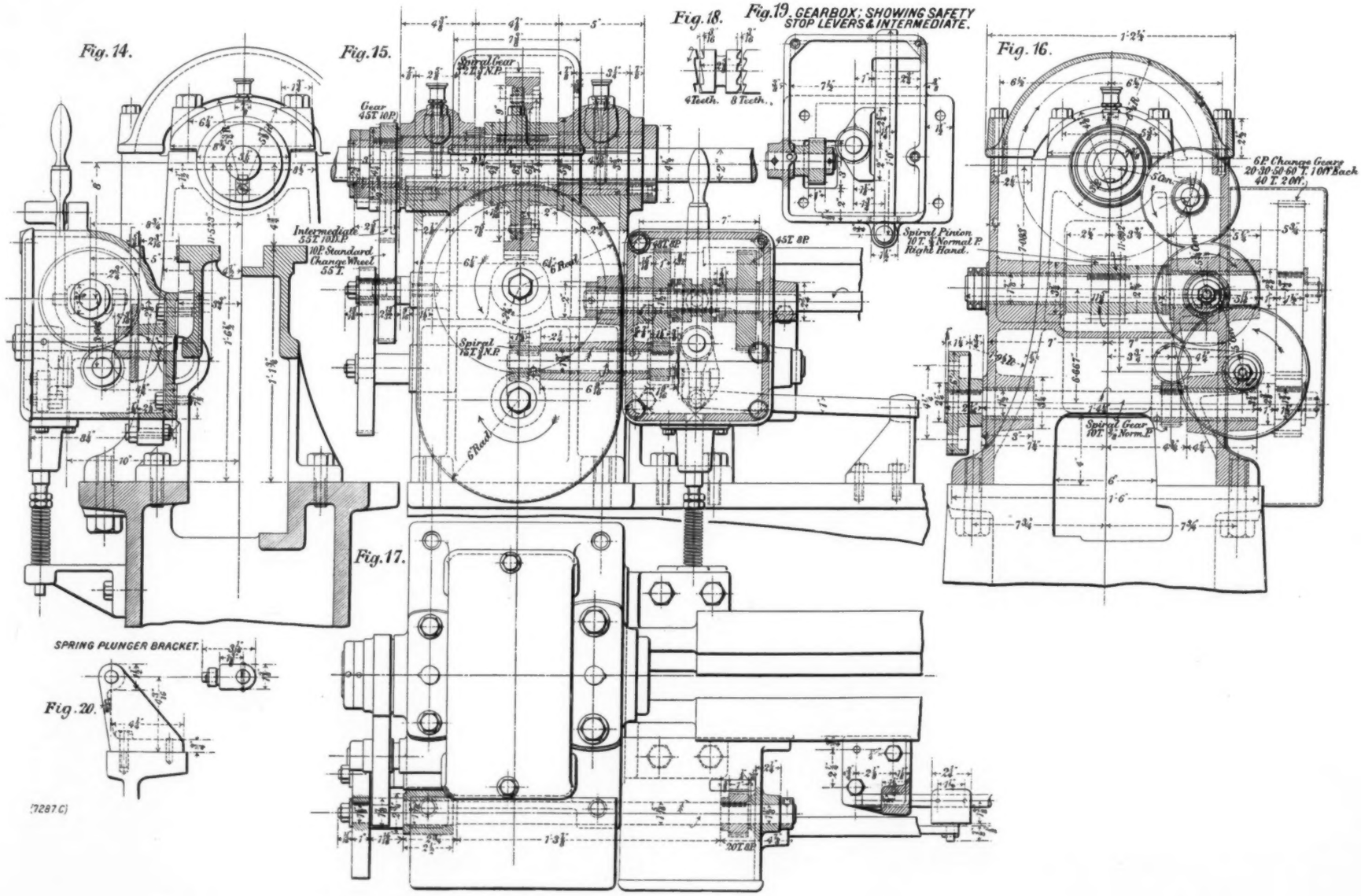
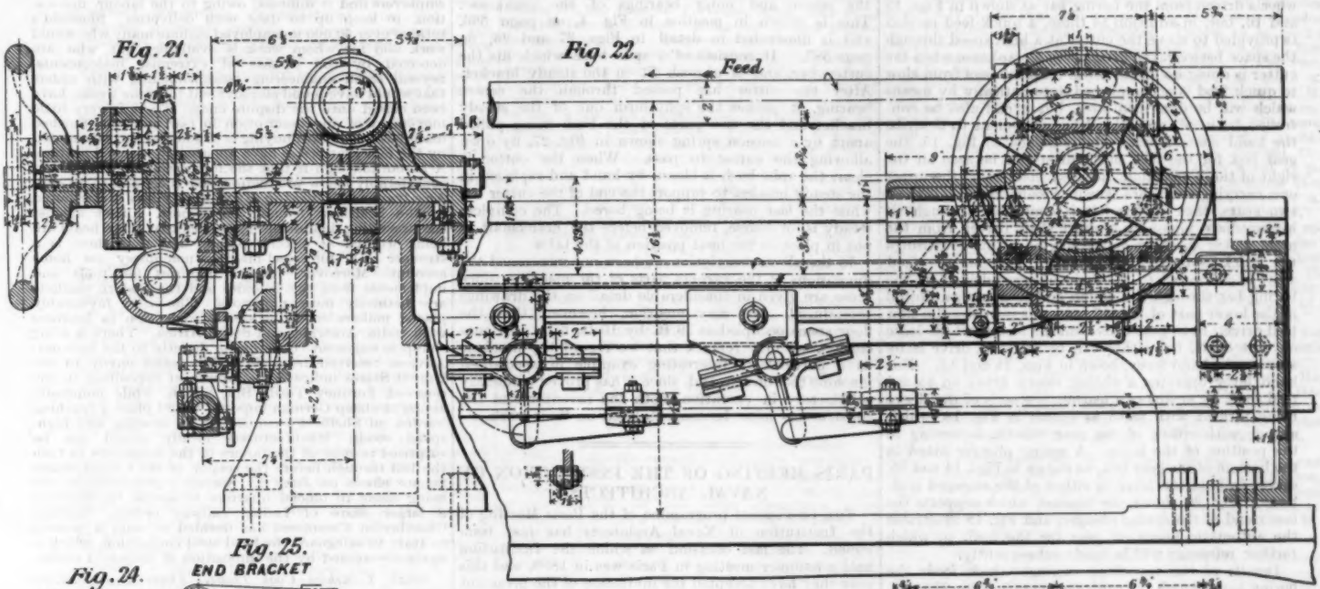
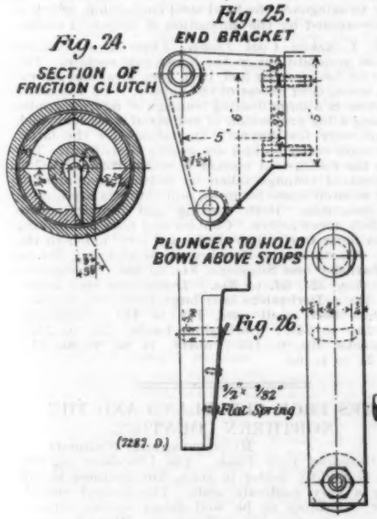


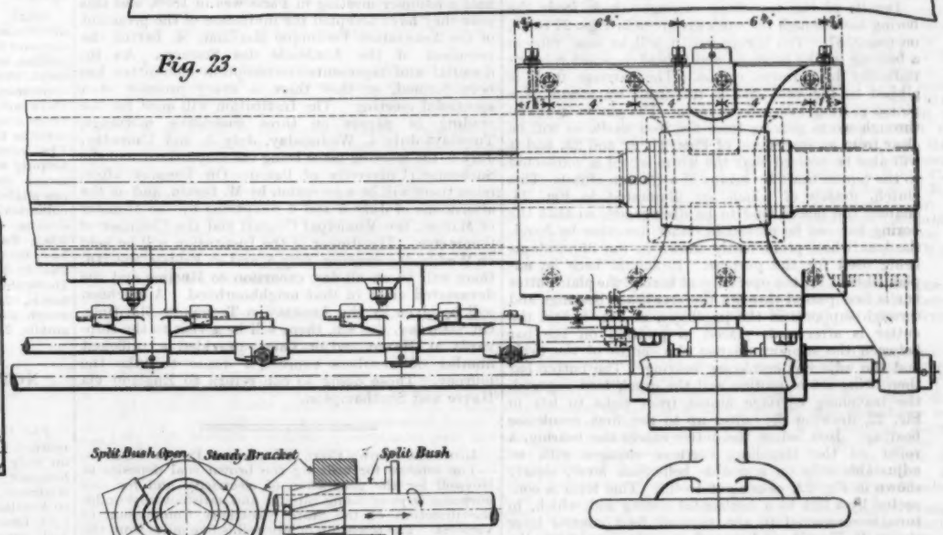
Fig. 14.
Fig. 15.
Fig. 16.
Fig. 17.
Fig. 18.
Fig. 19. GEARBOX: SHOWING SAFETY STOP LEVERS & INTERMEDIATE.
Fig. 20.
SPRING PLUNGER BRACKET.
(7287 C)
Spiral Gear 45T. 5 N.P.
Gear 45T. 10P.
Intermediate 55T. 10D.P.
10P. Standard Change Wheel 55 T.
Spiral 45T. 5 N.P.
6" Rad.
45T. 8P.
Spiral Pinion 10 T. 5 Normal P. Right Hand.
4 Teeth.
8 Teeth.
6P. Change Gears 20-30-50-60 T. 1 on Back 40 T. 2 on.
Spiral Gear 10T. 5 Norm. P.
50T. 8P.
20T. 8P.

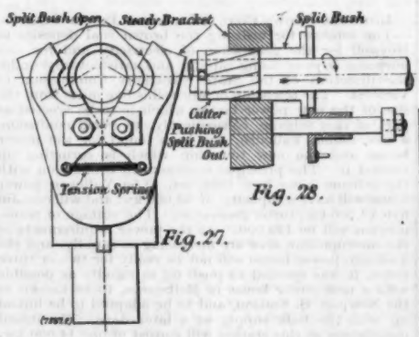
BORING AND RUNNING-IN MACHINE FOR MOTOR-OMNIBUS ENGINE CRANKCASES.

CONSTRUCTED BY MESSRS. JOHN HOLROYD AND CO., LIMITED, ENGINEERS, MILNROW.









taneously, one operator attending to each stage of the process, and to that stage only. Three crankcases can be finished per hour on this machine in ordinary work, whereas a fitter was formerly occupied for two days in finishing one crankcase. It may here be mentioned that any of the three different types of crankcase used in the Company's services can be dealt with on this machine by using suitable jigs.

Having explained the method of operating the machine in a general manner, we may now proceed to describe its construction in detail. Figs. 6 to 13 on Plate XXIV illustrate the driving and clamping arrangements for the table which can be rotated either by hand or by power taken from the running-in motor; the latter is of 30-h.p., and runs at 935 r.p.m. The horizontal shaft shown on the right of Fig. 6, which is driven from the running-in motor by gearing illustrated in Fig. 1, carries a dog clutch, which can be made to engage with a corresponding part formed on a worm running loose on the shaft, by means of the vertical hand lever shown on the left of Fig. 6. The worm engages with a worm wheel, which is connected to a short vertical shaft through a spring-controlled friction clutch, best shown in Fig. 13, and the shaft carries a pinion at its upper end which meshes with a geared ring attached to the under side of the table. The clutch is adjusted so that it slips if the table encounters any abnormal resistance to rotation, and thus acts as a safety device.

The final adjustment of the table is effected by means of the handwheel shown on the left of Fig. 6. This drives a horizontal shaft through a pair of mitre wheels, and the shaft can be connected to the worm which rotates the table by means of a second dog clutch operated by the vertical lever above referred to. As shown in Fig. 6, this hand lever is in the neutral position. When moved to the right, it puts the power drive for the table into gear, and when moved to the left it connects the worm to the handwheel, so that the table can be adjusted by hand. Details of the casting carrying the handwheel and lever are given in Fig. 8, while Fig. 9 is an end view of the arrangement. The table is located, so that the two arms in use for the boring and running-in operations are in exact alignment with the axis of the machine, by means of a sliding stop operated by a hand lever and most clearly shown in Fig. 7. The stop engages with a vertical projecting face of hardened tool steel fitted to the end of each arm of the table, and shown in detail in Fig. 12. The means provided for holding the table down to the bed of the machine at each end can be followed by examining Figs. 6 and 7 together with the details given in Figs. 10 and 11. The table can also be clamped centrally by means of a handwheel, screw and washer plate fitted to the pin on which the table turns; this feature will be clear on reference to Fig. 6. The gear box fitted at the right-hand end of the machine, as shown in Figs. 1 and 2, gives a ratio of 4·675 : 1 between the motor-shaft and the crankshaft for the purpose of running in the latter. A sliding sleeve, operated by a hand lever, is provided on the slow-speed shaft of the gear for connecting the latter to the crankshaft, a special connecting piece being attached to the end of the crankshaft for the purpose.

The remaining illustrations on Plate XXIV, *i.e.*, Figs. 14 to 20, show the driving arrangements for the boring bar. The drive is obtained from a 5-h.p. motor running at 940 r.p.m., and placed with its shaft at right angles to the length of the machine, as shown in Fig. 2, on page 586. The motor shaft is connected to the coupling shown on the left of Fig. 16, and the shaft carrying this coupling is connected to one above it by means of a pair of change wheels. The upper shaft carries a spiral pinion which engages with a spiral wheel mounted on a sleeve fitted with a feather,

and the feather fits in a slot cut in the boring bar, so that the latter can slide longitudinally while rotating. The change wheels provided give boring speeds ranging from 100 to 300 r.p.m., with a constant motor speed. Boring feeds, ranging from $\frac{1}{64}$ in. per revolution to $\frac{1}{8}$ in. per revolution, are obtained through a train of wheels driven from the boring bar as shown in Figs. 15 and 16, but, in addition to these, a quick-feed motion is provided to move the cutter at a high speed through the space between the bearings in a crankcase when the cutter is doing no useful work. The change from slow to quick feed is accomplished automatically by means which will be described later, but it can also be controlled by hand, and it will be convenient to describe the hand control first. On reference to Fig. 15, the gear box for the feed mechanism will be seen on the right of the illustration, the feed shaft being the upper one, carrying two gears shown cross-hatched. Of these two gears, that on the left is connected through an intermediate pinion to a short shaft driven from the main motor shaft by spiral gearing; this constitutes the quick-feed drive. The other gear on the feed shaft is connected to the train of gears driven by the boring bar through the pinion and shaft shown dotted in the lower part of Fig. 17, and this provides the slow feed drive. Both gear wheels on the feed shaft are loose on that shaft, but either can be made to drive it by moving the hand lever shown in Figs. 14 and 15. This hand lever operates a sliding sleeve fitted on to the feed shaft by means of a feather, the ends of the sleeve being formed with teeth as shown in Fig. 18, which engage with either of the gear wheels, according to the position of the lever. A spring plunger fitted in the bottom of the gear box, as shown in Figs. 14 and 15, serves to hold the lever in either of the engaged positions. Fig. 20 shows the bracket which supports the lower end of the spring plunger, and Fig. 19 illustrates the automatic knock-off gear for the feed, to which further reference will be made subsequently.

Details of the travelling carriage which feeds the boring-bar through the work are given in Figs. 21 to 26, on page 587. The boring bar, it will be seen, runs in a bearing on the carriage, and is held in position longitudinally by screwed collars. The carriage itself is gibbed to the bed, and is traversed by means of a pinion gearing with a fixed rack. The pinion is driven through worm gearing from the feed shaft, as will be clear from an inspection of Figs. 21, 22 and 23, and it will also be noticed that the worm wheel is connected to the pinion shaft by means of a friction clutch. This clutch, details of which are illustrated in Fig. 24, enables the power feed to be disengaged, so that the boring bar can be moved in either direction by hand, the handwheel prominently shown in the illustrations being used for the purpose. It should here be explained that for the operation of boring, the plain cutter bar is first passed through the crankcase bearings and through supports in the jig shown in Fig. 4, and the cutter is afterwards placed in position on the bar between the support nearest the centre of the table and the adjacent crankcase bearing. The cutter bar then being set in motion and the quick feed engaged, the travelling carriage moves from right to left in Fig. 22, drawing the cutter up to the first crankcase bearing. Just before the cutter enters the bearing, a roller on the travelling carriage engages with an adjustable stop on a double bell-crank lever, clearly shown in Fig. 22, causing it to tilt. This lever is connected by a link to a horizontal sliding rod, which, in turn, is connected to the vertical feed control lever shown in Fig. 15, and the effect is thus to draw the rod along to the left and throw in the slow feed as will be clear from the description of the mechanism given above. When the cutter has passed through the bearing, the roller engages with a second stop on the same bell-crank lever, causing the sliding rod to move in the opposite direction and thus engaging the quick feed. In this way the three bearings are bored out, the feed being automatically increased between each bearing as explained; a pair of stops fixed in the correct position is, of course, provided for each bearing. Finally, after the last bearing has been bored, the feed is again increased until the cutter bar is clear of the jig, so that the table can be rotated to bring the next crankcase into position. At the end of its travel, the carriage comes in contact with a stop on top of the gear case, which moves the feed lever into the mid, or neutral, position, thus disengaging both feeds. This stop can be seen on the left of Fig. 14, on Plate XXIV, between the feed lever and the bed of the machine, which is shown in section. From Fig. 19, it will be seen that the stop is in the form of a pivoted bar, which when brought into the vertical position by the travelling carriage, bears against both ends of a double lever on the feed-lever shaft. The feed lever is thus held in the neutral position until the carriage is moved clear of the stop. Fig. 25 shows the bracket supporting the ends of the feed shaft and the sliding rod, while in Fig. 26 are given details of the link carrying the roller on the travelling carriage and of the spring plunger provided to hold the roller clear of the stops when the travelling carriage is being moved by hand.

The only other detail which remains to be dealt with to complete our description of the machine is the movable steady used to support the cutter bar between the centre and outer bearings of the crankcase. This is shown in position in Fig. 4, on page 586, and is illustrated in detail in Figs. 27 and 28, on page 587. It consists of a split bush which fits the cutter bar, and is a push fit in the steady bracket. After the cutter has passed through the centre bearing, it pushes the split bush out of the steady bracket and the two parts of the bush being pulled apart by a tension spring shown in Fig. 27, fly open allowing the cutter to pass. When the cutter is clear, the split bush is closed by hand and replaced in the steady bracket to support the end of the cutter bar while the last bearing is being bored. The complete steady is, of course, removed before the crankshaft is put in place in the next position of the table.

In the above description we have not mentioned the dimensions of the various parts of the machine, since these are given in considerable detail on the drawings reproduced. We may mention, however, that the floor space occupied is 29 ft. by 10 ft. 6 in. In conclusion, we may remark that we regard the machine as a particularly interesting example of specialised machine tool design, and, since it has proved eminently satisfactory in operation, both the inventor and the constructors must be congratulated on their work.

PARIS MEETING OF THE INSTITUTION OF NAVAL ARCHITECTS.

THE provisional programme of the Paris Meeting of the Institution of Naval Architects has just been issued. The last occasion on which the Institution held a summer meeting in Paris was in 1895, and this year they have accepted the invitation of the president of the Association Technique Maritime, M. Bertin, the president of the Académie des Sciences. An influential and representative reception committee has been formed, so that there is every promise of a successful meeting. The Institution will meet for the reading of papers on three successive mornings, Tuesday, July 4, Wednesday, July 5, and Thursday, July 6, the meeting place being the amphitheatre of the Sorbonne (University of Paris). On Tuesday afternoon there will be a reception by M. Bertin, and on the afternoons of July 5 and 6 receptions by the Minister of Marine, the Municipal Council and the Chamber of Commerce. The dinner of the Institution will be held on Wednesday evening, July 5, and on Friday, the 7th, there will be an all-day excursion to Rheims and the devastated areas in that neighbourhood. A luncheon will be given by the Association Technique Maritime. On Saturday, the 8th, there will be a visit to the shipyards at Havre and/or Caen, provided a sufficient number of members express a desire to take the journey. Those doing so can return to England via Havre and Southampton.

MORWELL BROWN COAL: YALLOURN POWER STATION.—The scheme for utilising the brown coal deposits at Morwell for the generation of electricity and for fuel purposes is progressing rapidly and satisfactorily under the direction of the State Electricity Commission of Victoria. The township of Morwell is five miles from the site of the new power house, which is to be erected as part of this scheme, consequently, to avoid confusion, a new name, Yallourn, has been found for the power house and the new township which is springing up around it. The principal contracts in connection with the scheme have how been let. The Yallourn power house will have a capacity of 50,000 kw. and will contain five 12,500 kw. turbo generators. The voltage of transmission will be 120,000. As the power requirements of the metropolitan area are increasing so rapidly, and the Yallourn power house will not be ready for two or three years, it was decided to push on as rapidly as possible with a new power house in Melbourne, to be known as the Newport B. Station, and to be adapted to be linked up with the bulk supply at a later date. The initial installation at this station will consist of one 14,000 kw. turbo generator, with a second generator of similar size as a standby. It is hoped that this station will be in operation by May, 1923. As regards fuel the Commission anticipates that it will be in a position, in June, 1922, to supply to the public raw brown coal from Morwell. An inclined approach to the surface of the coal is being constructed and two "Bucyrus" shovels with a capacity of 2¼ and 3½ cubic yards repectively will be used for excavating both the overburden and the coal. The landed cost of the two shovels will be about 58,000*l*. From the open cut, the coal will be transported to a crushing and screening plant by a system of endless rope haulages. In view of the encouraging results obtained in other parts of the world from the use of pulverised black coal as a fuel, the Commission intends to install an experimental plant for the production of brown coal in powdered form and to investigate its suitability for locomotives and stationary boilers.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Conditions throughout the whole of the heavy sections are overshadowed by the failure to arrive at a settlement in the engineering dispute. Orders are scarce in forges and foundries, but even so employers find it difficult, owing to the labour dislocation, to keep up to date with deliveries. Sheffield's total of over 50,000 unemployed include many who would work and for whom work is available, but who are deterred by the threats of extremist malcontents. Several small engineering establishments, with orders that would have found employment for some weeks, have been closed until the dispute ends. There is very little movement of any description in raw and semi-finished materials. Forward buying is to some extent stimulated by the fact that prices have apparently touched bottom. A favourable sign is that the forced selling of materials considerably below production cost is coming to an end. An advance of 5*s.* per ton in soft basic billets is attributed to the healthier demand for export. Offset against the prevailing depression is the fact that more heats are being worked at electric plants, and that there is a stronger call for steel-making machinery on home account. Moreover, foreign inquiries for tools and implements from the Colonies and the eastern markets are distinctly more numerous. The more favourably placed makers report a steady expansion in business with India, Australia and South Africa. There is a big slump in engineers' tools owing directly to the lock-out. Advices received from Sheffield's steel envoy to the United States indicate the growth of opposition to the renewed Fordney Tariff Bill, which, while nominally aimed at cheap German imports, would place a crushing burden on Sheffield's connection in crucible and high-speed steels. Manufacturers locally would not be surprised to hear of the failure of the promoters to rush the Bill through before the session of the United States Senate closes on June 1. Special representations are being made in official quarters to secure for Sheffield a larger share of Indian railway orders. Sheffield Chamber of Commerce has decided to send a mission to Italy to safeguard the local steel connection, which is again threatened by the imposition of increased tariffs.

South Yorkshire Coal Trade.—There is a striking difference in conditions in the house coal section. The demand for best quality fuel, both from local and Metropolitan areas, is in excess of the supply. On the other hand, there is a large floating tonnage of inferior grades containing a big proportion of industrial sorts for which there are very few buyers. Quotations for the latter show a wide variation and are mostly downward. The tone in the steam coal market is rather more cheerful. The increased tonnage taken by railway companies is helping to swell home business, and shippers are buying larger quantities. Both melting and foundry cokes are slightly more active. Cobbles and nuts are leaving collieries more freely, but slacks are very much in the dumps. Quotations:—Best branch handpicked, 38*s.* to 39*s.*; Barnsley best Silkstone, 34*s.* to 36*s.*; Derbyshire best brights, 32*s.* 6*d.* to 34*s.*; Derbyshire best house, 26*s.* to 28*s.*; Derbyshire best large nuts, 24*s.* to 26*s.*; Derbyshire best small nuts, 16*s.* to 18*s.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 10*s.* to 12*s.*; nutty, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 2*s.* to 4*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The Cleveland pig-iron market is slightly better in tone, but business is still on only a very moderate scale. The limited output, however, continues to be well taken up by running contracts, and values are well upheld. What few sales to Scotland are being put through are based on 96*s.* 8*d.* f.o.t. Grangemouth for No. 3. Terms for all other home and export business in Cleveland pig-iron are f.o.t. makers' works or f.o.b. Tees, and remain: No. 1—which is still very scarce—and siliceous iron, 95*s.*; No. 3 G.M.B., 90*s.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 85*s.*; and mottled and white, 80*s.*

Hematite.—On the whole the hematite situation is less satisfactory than it has been. One or two producers have fairly good contracts in hand, and are loath to make price concessions. Such firms continue to ask up to 97*s.* 6*d.* for Nos. 1, 2 and 3 East-Coast brands, but others less favourably placed are keen sellers on considerably lower terms. Some makers are short of work, and readily accept home orders at 96*s.* for mixed Nos. Export quotations vary a good deal. Sales for abroad have been made at 95*s.* and even less, but several sellers ask up to half-a-crown above that figure.

Iron Sales to America.—In the present state of inactivity it is pleasing and encouraging to learn of sales of iron to the United States. A number of inquiries from across the Atlantic are reported, and they have already resulted in some business. Rather considerable shipments of ferro-manganese to America have been arranged, and a few thousand tons of Cleveland pig-iron are understood to have been sold to the States.

Foreign Ore.—Business in foreign ore is hardly heard of, sales seemingly being still confined to transactions in odd cargoes. Deliveries against old contracts, however, are heavy, imports to the Tees so far this month being at the rate of something like 8,000 tons per working day. Best rubio is on sale at 27*s.* c.i.f. Tees, and up to 23*s.* 6*d.* c.i.f. Tees is named for good Mediterranean ores.

Coke.—Buyers report coke easier, but sellers are very

loath to acknowledge that such is the case, and certainly up to 28*s.* delivered has still to be paid for early supply of Durham medium blast-furnace sorts. Possibly forward contracts could be arranged on substantially lower terms, but sellers generally were not disposed to commit themselves ahead to any great extent.

Manufactured Iron and Steel.—Little new is ascertainable concerning manufactured iron and steel. Extreme quietness prevails in most departments, and producers are generally badly off for work, but in one or two branches inquiries are slightly better. Export quotations are substantially below the following rates, which are among the principal market prices for home business:—Common iron bars, 12*l.*; iron rivets, 14*l.*; steel billets (medium), 8*l.* 5*s.*; steel billets (hard), 8*l.* 15*s.*; steel boiler plates, 14*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; heavy sections of steel rails, 9*l.* 10*s.*; fishplates, 14*l.* 10*s.*; black sheets, 12*l.* 5*s.*; and galvanised corrugated sheets, 15*l.* 15*s.* to 16*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Trade Outlook.—A rather better tone has been noticeable in the state of trade in general in the West of Scotland during the past week. This is largely accounted for by the agreement arrived at in the shipbuilding trade, and as quite a satisfactory re-start has been made by the men in most of the yards, the outlook is considered fairly bright. The scarcity of orders is the chief fly in the ointment meantime, but as building costs, and likewise repairing and fitting-out charges, will all be lower now there are great hopes that order books will soon show the long anticipated improvement. The immediate effect of the resumption of work in the yards means a demand for steel and other material, and inquiries all round are a bit better this week. A more hopeful feeling has overtaken business circles during the past day or two, and if the trouble in the engineering trade could only be surmounted, the outlook in the West of Scotland would be fairly satisfactory. Export trade of all kinds is quiet, the rates of exchange being against much revival, but, as home costs come down, as they assuredly must, in the near future, the shipping trade will open out in all branches of industry, as many of our foreign markets are very bare of supplies.

Scottish Steel Trade.—Little change has taken place as yet in the steel trade of Scotland, but there are indications of some improvement now that the shipyards have again got started. Producers have found it very difficult to carry on during the past few weeks and the output has been exceedingly poor. Inquiries are again a little better, and everything points to the fact that many consumers of steel material are very short of stock, and that they are almost certain to come into the market very soon. Black sheet makers are still quiet, but there have been more inquiries going about and there are prospects of a number of these coming to actual business shortly. Foreign buyers show more inclination to place orders again, but no great volume is expected for the present, as our prices are considered still a shade stiff. Current quotations are as follow:—Boiler plates, 14*l.* per ton; ship plates, 10*l.* 10*s.* per ton; Sections, 10*l.* per ton; and sheets, ¼-in., 11*l.* 15*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The conditions in the West of Scotland malleable-iron trade are not any better, and the price concessions made recently have utterly failed to induce local buying. The general trade conditions have certainly been all against consumers placing orders forward, but as the outlook has improved, a better demand is now expected. Foreign buyers have been doing a little better of late, but the export trade overall has not been very heavy. Prices are unchanged with "crown" bars called 11*l.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—Nothing fresh falls to be recorded in connection with the Scottish pig-iron trade and the position is really unaltered. Consumers do not yet appear inclined to order anything beyond their actual requirements, but foreign buyers have been more in evidence, and one or two fair lines have been booked. Inquiries from abroad are also rather better, and if only a settlement of the dispute in the engineering trade were reached, there would assuredly be a more healthy tone in the pig-iron industry. The following are the current quotations:—Hematite iron, 5*l.* 5*s.* per ton, delivered at the steel works; No. 1 foundry iron, 4*l.* 17*s.* 6*d.* per ton; and No. 3 quality, 4*l.* 12*s.* 6*d.* per ton, both ex makers' works.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Stoppages in the Welsh coalfield against the employment of non-unionists are threatened by the South Wales Miners' Federation. At a meeting on Monday last it was decided to inaugurate a campaign for bringing back to the Federation ex-members and non-members. This campaign is to continue till the annual meeting, which takes place in June, and if the campaign is not successful it has been decided to revive the policy of striking against the employment of non-unionists. Meanwhile coalowners and exporters continue to regain foreign markets, for shipments in April, though less than in March in the aggregate, showed on the average further expansion. In all 1,753,002 tons of coal were despatched abroad, which was 392,556 tons less than in March. The daily average rate of shipments was, however, 200 tons more than in March, because in April there were only 22 working days compared with 27 in March. In the four months ending April exports amounted to 7,544,913 tons, compared with 2,942,119 tons in the corresponding period of last year, an increase of 4,602,794 tons, representing an improvement of over 150 per cent. Exports in the first four months of this year were roughly two and a-half times greater than in the corresponding period a year earlier. Of the April shipments 531,300 tons went to France, 261,300 tons to Italy, 262,400 tons to South America, 142,600 tons to Spain, 77,700 tons to Portugal, 6,000 tons to Greece, 175,300 tons to British coaling depots, and 296,300 tons to other countries. Shipments to South America were the greatest for any month of the past two years, the increase being partly due to the American strike. In fact, in the past fortnight 25 vessels of 130,300 tons carrying capacity have been chartered to transport coal to the Argentine. Meanwhile conditions on the coal market show little change. Prices are steady on the basis of 28*s.* 6*d.* for best Admiralty large and 19*s.* 6*d.* for best steam smalls. While the demand for prompt loading is relatively small inquiries for shipment ahead are rather numerous, but whether they will mature remains to be seen. The Germans are asking tenders for 50,000 tons of large coal, delivery over three months, the Palestine railways want 15,000 tons in three cargoes, the French State Railways require 20,000 tons of small and 4,000 tons of large, and there are inquiries for single cargoes to North American ports.

Iron and Steel Trades.—Though the prices of Welsh tin-plates have developed an easier tone the market generally remains steady, and inquiries are stated to be expanding. The fact that plates are now being shipped to 23 different countries is regarded as an indication that the Welsh trade is steadily regaining its pre-war position. Current prices are round 19*s.* 6*d.*

THE JUNIOR INSTITUTION OF ENGINEERS: CANET LECTURE.—At the council's invitation, the Right Hon. Sir Eric Geddes, G.C.B., G.B.E., has kindly consented to deliver the Fourth Canet Lecture. To ensure adequate accommodation for the large attendance expected, arrangements have been made, by courtesy of the council, for the meeting to be held in the Lecture Theatre of the Institution of Electrical Engineers, Savoy-place, Victoria Embankment, W.C. 2, on Thursday, June 1. The chair will be taken by Mr. C. H. Wordingham, C.B.E. (president of the Institution), at 7.30 p.m.

ELECTRICITY DISTRIBUTION AT 220,000 VOLTS.—In a report published in a recent issue of the *Annales des Ponts et Chaussées*, M. H. Isaarte refers to the two projects for the distribution of electricity at 220,000 volts now well advanced in the United States. One of these is for a line from Pitt River to San Francisco, promoted by the Pacific Gas and Electric Company. This scheme has got well past the initial stages, the plans being complete and the material ordered, whilst it is intended to proceed this spring with the actual work of construction. The ultimate intention is to transmit 325,000 kw., the distance between termini being nearly 200 miles. The second project is to raise the voltage on the line from Big Creek to Eagle Rock, Los Angeles, from 15,000 volts to 220,000 volts.

THE IRON TRADES EMPLOYERS' INSURANCE ASSOCIATION, LIMITED.—The report for 1921 has been issued of the above company, which is in effect the insurance department of the Engineering and National Employers' Federation, and is limited entirely to engineering and shipbuilding firms who are members of these federations. The premium income amounted to 696,644*l.*, which with 73,204*l.* dividends and interest on invested funds, made the total receipts 769,848*l.* The amount paid and provided in respect of compensation and incidental expenses during the same period amounted to 466,134*l.* There remains a balance on revenue account of 403,175*l.*, out of which the directors propose to make a return of premium at the rate of 40 per cent. among the present policy-holders of the Association entitled thereto. The directors, who retire by rotation and, being eligible, offer themselves for re-election, are Sir John Dewrance, K.B.E., Mr. George Jones, Sir William Thom, K.B.E.

THE POWER SUPPLY OF THE UNITED STATES.—Statistics compiled for the Senate of the United States indicate that in 1919, 68·2 per cent. of industrial power requirements of America was supplied from isolated plants, while 31·8 per cent. was supplied by central stations. When the 1919 census was taken there were 290,105 industrial establishments being operated in the United States, with an aggregate horse-power rating of 29,575,242. At 237,855 of these plants 116,158 steam engines furnished 13,839,744 h.p.; 6,472 steam turbines furnished 3,258,235 h.p.; 33,407 internal-combustion engines furnished 1,259,394 h.p.; 13,244 waterwheels furnished 1,753,548 h.p., and 817 water motors furnished 22,165 h.p. In addition to the foregoing equipment, which is owned by the establishments, 9,442,156 h.p. were furnished by rented equipment. Of that amount 9,347,556 h.p. were furnished to 996,000 electric motors. The total number of electric motors in use in these plants was 1,483,039, with an aggregate rating of 16,317,383 h.p. The number of motors run by energy generated in the establishment was 487,039. Their combined horse-power was 6,969,827. The capital invested in the industrial plants of the country in 1919 was 44,688,093,771 dols. They employed 10,160,107 wage earners and 1,447,227 salaried employees. The amount of fuel used by these industrial plants was as follows: Bituminous coal, 203,452,724 short tons; anthracite coal, 14,545,300 long tons; coke, 142,764,287 short tons; oil, 92,608,186 barrels; gasoline, 2,344,469 barrels; natural gas, 305,768,321,000 cub. ft.; manufactured gas, 38,522,330,000 cub. ft.

NOTICES OF MEETINGS.

THE INSTITUTE OF TRANSPORT.—Tuesday, May 16, 7 to 10 p.m. Reception by the President at the Hotel Metropole. Wednesday, May 17, at 9.30 a.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. 1, the President will open the Congress and welcome English and foreign delegates. Papers to be read and discussed: In the lecture theatre, at 10 a.m., "Recent Improvements in Transport Facilities in the Port of London," by Sir Cyril Kirkpatrick; at 11.15 a.m., "Wireless as an Aid to Transport," by Captain M. H. P. Riall Sankey, C.B., C.B.E. In the reading room, at 10 a.m., "The Design, Construction and Maintenance of Highways in Relation to the Development of Mechanically-Propelled Vehicular Traffic," by Colonel C. H. Bressey, O.B.E. In the evening, from 8 till 11 p.m., Lord Mayor's Conversazione at the Mansion House. Thursday, May 18, in the lecture theatre, at 10 a.m., "Inland Water Transport—A Practical Policy," by Mr. Neville Chamberlain, M.P. In the reading room, at 10 a.m., "The Future Design of Road Vehicles for Passenger and Goods Services," by Sir J. E. Thornycroft, K.B.E. In the evening, 7 for 7.30, the Third Dinner of the Institute, Savoy Hotel. Friday, May 19, at 10 a.m., in the lecture theatre, "The Finance of the Modern Highway—A Problem and a Solution," by Mr. Dixon H. Davies; at 10 a.m., in the reading room, "Foreign Railway Practice," by Professor J. Carlier; at 11.15 a.m., "'Safety' in Railway Operation," by Colonel J. W. Pringle, C.B. At 5 p.m., at the Royal Society of Arts, Adelphi, "The Operation of Heavy Suburban Passenger Services on a Steam Railway, with Particular Reference to Density of Service, Terminal and other Facilities," by Mr. F. V. Russell, C.B.E.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Wednesday, May 17, at 3 p.m., at the Institution of Electrical Engineers, Victoria Embankment, resumed discussion on paper, "Some Recent Developments of Token Working on Single-Line Railways," by Mr. W. S. Roberts (Member).

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, May 17, at 5 p.m., at 49, Cromwell-road, South Kensington, the following papers will be read: (1) "Weather and the Crop-Yield in the North-East Counties of Scotland," by Mr. A. E. M. Geddes, O.B.E., M.A., D.Sc. The paper will be followed by a general discussion on Mr. R. H. Hooker's presidential address, "The Weather and the Crops in Eastern England, 1885–1921" (*Quarterly Journal*, April, 1922, pages 115 to 138), by Mr. Hooker's special request. It is hoped that the following will take part in the discussion: Sir A. D. Hall, K.C.B., F.R.S. (Chief Agricultural Adviser to the Ministry of Agriculture); Sir T. H. Middleton, K.B.E., C.B. (Development Commission); Dr. E. J. Russell, F.R.S. (Director Rothamsted Experimental Station); Mr. G. Udny Yule, F.R.S. (Agricultural Department, Cambridge University). (2) If time permits: "A New Form of Direct-Reading Barometer," by Mr. H. P. Waran, M.A., Ph.D., F.R.A.S.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, May 18, at 6 p.m., the Thirtieth Kelvin Lecture, "Electricity and Matter," by Sir Ernest Rutherford, K.B.E., F.R.S.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, May 18, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, London. The eighth ordinary general meeting of the thirty-first session of the Institution of Mining and Metallurgy will be held, by kind permission. The following Papers will be submitted for discussion: "The Treatment of Pyritic Concentrates Containing Tin," by Cyril W. Gudgeon, Member. "Clean Reef-Mining and its Influence on Mining Costs," by L. G. Hutchison, Member.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 19, at 8 p.m., at Caxton Hall. Lecturette, "Engineering Business in China," by Mr. F. W. G. Clark, A.M.I.Mech.E.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 19, at 9 p.m., Sir William Bragg, K.B.E., D.Sc., F.R.S., M.R.I., on "The Structure of Organic Crystals." Afternoon Lectures, at 3 p.m.: Tuesday, May 16, Mr. William Bullock, M.D., LL.D., F.R.S., on "Tyndall's Biological Researches and the Foundations of Bacteriology" (the Tyndall Lectures) (Lecture I); Thursday, May 18, Professor F. Keeble, O.B.E., Sc.D., F.R.S., on "Plant Sensitiveness. II. To Contact and to Chemical Stimulation"; Saturday, May 20, Professor O. W. Richardson, D.Sc., F.R.S., on "The Disappearing Gap between the X-Ray and Ultra-violet Spectra. (II) Photo-Electric Methods."

SURVEY OF THE YORKS., NOTTS. AND DERBYSHIRE COALFIELD.—The Fuel Research Board of the Department of Scientific and Industrial Research, has had under consideration for some time the question of the physical and chemical survey of the coal seams of Great Britain, but the unstable conditions which prevailed in the coal industry during and since the war have necessarily led to the postponement of the work of organisation. In the meantime, however, work has been in progress on the collection and correlation of the data already available. The amount of information that can be thus drawn upon varies greatly in relation to the several coalfields. In the case of the Yorkshire, Nottinghamshire and Derbyshire coalfield, the records already in existence which have been collated have been published by H.M. Stationery Office in the form of a report, price 2*s.* net. Copies may be obtained through any bookseller or from H.M. Stationery Office in London, Manchester, &c.

BORING AND RUNNING-IN MACHINE FOR MOTOR-OMNIBUS ENGINE CRANKCASES.

CONSTRUCTED BY MESSRS. JOHN HOLROYD AND CO., LIMITED, ENGINEERS, MILNROW.

(*For Description, see Page* 586.)

FIG. 29.

FIG. 30.

ENGINEERING.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick paper copies	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.

BELGIUM, Brussels: E. F. Satchell, 86, Rue de Tabellion.

CANADA, Toronto, Ont.: Wm. Dawson and Sons, Limited, 87, Queen Street, East.

EDINBURGH: John Menzies and Co., 12, Hanover-street.

FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.

GLASGOW: William Love.

INDIA, Calcutta: Thacker, Spink and Co., Bombay; Thacker and Co., Limited.

ITALY: U. Hoepli, Milan.
Anonima Libraria Italiana, Torino.
And any post office.

LIVERPOOL: Mrs. Taylor, Landing Stages.

MANCHESTER: John Heywood, 143, Deansgate.

NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.

NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.

ROTTERDAM: H. A. Kramer and Son.

SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elisabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Wm. Dawson and Sons (South Africa Limited, 20 and 21, Long-street, Capetown.

TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements: J. S. Allan, 90, Church-street, New York.

CONTENTS.

	PAGE
The International Railway Congress at Rome	575
Automobile Ignition (*Illus.*)	578
British Siemens Furnace Practice (*Illus.*)	579
The Late Mr. Alexander Cleghorn	583
Industrial Notes	583
Mechanical Stoking at Sea (*Illus.*)	584
Boring and Running-In Machine for Motor Omnibus Engine Crankcases (*Illus.*)	586
Paris Meeting of the Institution of Naval Architects	588
Notes from South Yorkshire	588
Notes from Cleveland and the Northern Counties	588
Notes from the North	589
Notes from the South-West	589
Notices of Meetings	589
Imperial Wireless Communication	591
The Economics of Main Line Electrification	592
The Relations of the Elements	592
The Immunity of Public Ships	593
The Iron and Steel Institute	593
The Inquiry into the Engineering Dispute	596
Notes	596
Letters to the Editor.—"Statically Indeterminate and Non-Articulated Structures." "Oil-Fuel Burning." "Low-Temperature Carbonising." "Failure by Fatigue."	598
Notes on Blast Furnace Filling (*Illus.*)	599
Some Post-War Problems of Transport (*Illus.*)	603
The Effect of Oxidising Gases at Low-Pressure on Heated Iron (*Illus.*)	605

Two-Page Plate.—BORING AND RUNNING-IN MACHINE FOR MOTOR OMNIBUS ENGINE CRANKCASES.

ENGINEERING.

FRIDAY, MAY 12, 1922.

IMPERIAL WIRELESS COMMUNICATION.

In view of the extent and configuration of the British Empire, and in view of the leading position which this country has taken in the development of wireless telegraphy, it is far from satisfactory that no general wireless system for the Empire is yet either in being, or in progress. In contrast to this state of affairs the United States, France and Italy have wireless chains either in operation, or nearing completion. Our backwardness in this matter is to some extent due to the war, although similar conditions affecting other countries do not appear to have led to similar results. There is little doubt, however, but that the general socialistic spirit which is abroad in this country has shaped the matter unfavourably. There is a hankering after State enterprise coupled with a reluctance to involve State funds and accompanied by a definite dislike to turning things over to private enterprise. The business man might imagine that all public and State rights could be adequately safeguarded in an agreement with private enterprise, but Parliament apparently considers such an agreement as almost an impossibility. In view of the fact that most of its own enactments have later to be interpreted and explained in a court of law, perhaps this belief is excusable.

Before and during the early stages of the war an Empire chain was in progress, but on the instructions of the Government it was abandoned in January, 1915. The contract was between the Postmaster-General and the Marconi Company, and one result of the abandonment of the project was that the company brought an action for breach of contract, and, in July, 1919, obtained damages of 590,000*l.* This may, or may not, have been satisfactory to the Marconi Company, but it hardly helped forward the establishment of the Empire chain which is the matter in which the public and the countries of the Empire are interested. This original scheme was begun in March, 1914, and, apart from further inquiries and committee work, all that has been done since its abandonment has been the granting of 170,000*l.* to the Post Office to equip the Leafield and Cairo stations, which formed part of the original scheme and were abandoned in the first year of the war.

The present condition of affairs is that a committee under the chairmanship of Sir Henry Norman, which was appointed after the war to reconsider the whole subject, reported in the early part of 1920. They recommended a chain of stations for erection in England, Egypt, India, Singapore, Hong Kong, in Northern or Western Australia, in East Africa and South Africa. The stations in England and Egypt were to be of modern type and additional to the Post Office stations at Leafield and Cairo. The committee further recommended that the Post Office Engineering Department and the corresponding departments overseas should be given responsibility for making contracts with private engineering firms and supervising construction. It was also recommended that a small expert commission should be appointed for planning the stations and advising generally during erection. This Commission, of which Lord Milner is the chairman and Dr. Eccles the vice-chairman, was appointed at the end of 1920 and reported last December. A summary of the work of the Commission and a survey of the whole subject of the Imperial wireless chain were given in a clear and able paper read by Dr. Eccles before the Dominions, and Colonies and Indian Section of the Royal Society of Arts, on the 5th inst.

Presumably the recommendations of this Commission have been digested by some one in authority, but it is not clear from Dr. Eccle's paper that anything further has resulted. It is surely time that some definite project was taken in hand and carried through. The whole subject is obviously one which cannot be dealt with by the British Government alone, but we imagine that nothing but a business-like response would come from the Colonies and India in reply to a businesslike proposal from this country. The original scheme which was abandoned in 1915 was the outcome of the deliberations of a Joint Committee representing Government Departments, Australia, New Zealand, South Africa and India. The first proposed contract with the Marconi Company was not ratified by Parliament, and it was only after further inquiry by a Select Committee of the House of Commons and an Advisory Committee, presided over by Lord Parker, that a contract was entered into. The work of the original joint committee representing this country and several of the Colonies lay at the back of what was done, however, and the time now appears to be more than ripe for some similar arrangement and a proper setting to work again. There appears no advantage and many disadvantages in Canada remaining outside any Imperial wireless scheme, yet even now the proposals of the latest committee do not include Canada, which is left for future consideration. The whole subject appears to be waiting for someone who will get something done. The matter is by no means purely one for the Post Office; service considerations, for instance, are of great importance, but if someone in authority would get to work seriously all relevant interests could easily be brought in. Possibly Mr. Kellaway, having disposed of his post card and telephone critics for the time being, may find opportunity to investigate the subject.

The scheme which has been recommended by the Norman Committee, and which is now, more or less, before the country, is based in a general way on steps of 2,000 miles between transmitting and receiving stations, and steps not seriously greater than this magnitude appeared to be considered by Dr. Eccles to be necessary if continuous working is to be ensured. This condition, stated in this way is, of course, purely a technical matter, and many will certainly think that Dr. Eccles is unduly conservative in his estimate. Senator Marconi, who spoke after the reading of the paper, disagreed entirely on the point.

In this connection it must be remembered that a reasonably satisfactory service was carried on across the Atlantic in 1909, involving a distance not greatly different from the 2,000-mile standard. Very remarkable progress has been made in the design of wireless apparatus since that year, and it would not appear unreasonable to suggest that a greater range is now possible. It is not to be supposed, however, that Dr. Eccles is not

fully acquainted with all that has been done in long-distance wireless. His point is not that work cannot be carried on over greater distances than 2,000 miles, but that for 24-hour, day-in and day-out operation seriously longer distances than this will involve periods when work will be very difficult, or even impossible. As bearing on this question he pointed out that in the United States chain linking Washington with Central America and California, and through Honolulu and Guam with the Philippines, most of the steps are of the 2,000-mile order, except that from Honolulu to Guam, which is 4,800 miles. This step is, of course, dictated by purely geographical considerations, and in any case is entirely over water which in general leads to easier operation. In the French military chain linking Paris with the Soudan, the Congo, Antannanarivo, Pondicherry and Cochin China, the steps are all about 2,000 miles except that from Antannanarivo to Pondicherry, which is 3,100 miles. Similarly, in the Italian State chain, the longest step is 2,800 miles. In the German chain, lost during the war, the distance from Nauen to Kamina was 3,400 miles, and Dr. Eccles states this "proved too great for real work." Windhuk, the next station, was nearly 2,000 miles south of Kamina, and Dr. Eccles states it is believed to have exchanged scarcely any signals successfully during its short active life. On this point, Mr. Godfrey Isaacs, who spoke at the meeting, pointed out that the German chain was efficient enough at the outbreak of war to enable the Germans to communicate with their mercantile marine so that most of it evaded capture. This point need not be disputed, but it does not dispose of Dr. Eccles' contention. The Germans may have been fortunate in the wireless conditions at the time, and in any case the matter was only one of receiving signals from the powerful station at Nauen. The question of a 24-hour regular service in both directions does not come in.

This technical question of the longest possible step for satisfactory everyday service is of interest, but it really does not rise in an acute form as far as any British Empire chain is concerned. We do not wish to jump merely from England to Australia. We wish to link the various parts of the Empire together. The present scheme, as we have said, is for stations in England, Egypt, India, Singapore, Hong Kong, Northern or Western Australia, East Africa and South Africa. An alternative arrangement with five big stations and giving longer steps has been suggested. This would cover England, Vancouver, Australia, South Africa and India. Dr. Eccles suggests that such a scheme would probably not be remunerative, since the possible hours of satisfactory working would not be sufficient to properly employ the capital invested. This, as we have said, is a matter of technical opinion, but as it will be admitted that there are no places in the 2,000-mile scheme which it would not be desirable to touch, that appears the more suitable proposal. As Dr. Eccles points out, when conditions are good, through messages need not be relayed at intermediate stations, and full advantages can be taken of the best than can be done. When, on the contrary, conditions are bad, satisfactory and continuous communication should still be possible by relaying at intermediate points. Further, the relay stations would all be in important places, and the whole scheme would ensure not only satisfactory communication between this country and all parts of the Empire, but also satisfactory intercommunication between the outlying parts.

THE ECONOMICS OF MAIN LINE ELECTRIFICATION.

THAT the question of the electrification of main line British railways is rapidly advancing beyond the academic stage is illustrated, among other ways, by the number of important papers dealing with the subject—which have been read by leading railway men and others before various of our technical institutions during the last year or so. The latest addition to the list was read by Mr. Roger T. Smith before the Institute of Transport last Monday. The subject in general terms has been already well discussed, and a useful summary of the present position was furnished by the joint discussion of the Civil, Mechanical and Electrical Engineers' Institutions held in Birmingham and reported in our issue of January 27 last. Instead of dealing again with the general consideration affecting the question, Mr. Roger Smith wisely narrowed his ground and concerned himself with recent improvements in equipment making for economy. This limitation still left the subject a wide one, and necessarily resulted in a paper having something of an omnibus character. None the less, the aspect of the question to which Mr. Smith addressed himself is without question, the most important. British main line electrification is now an economic question, not a technical one, and any technical advances which will reduce capital or working costs must affect the outlook very closely.

We cannot now deal with all the points raised in the paper, but one appeared to concern possible developments of such outstanding importance, that we must give it a little attention. Dealing with the cost of generation and transmission, Mr. Smith took the cost of a 50,000 kw. station with a 50 per cent. load factor at 19*l.* 6*s.* per kilowatt, and that of a 6,000 kw. station with the same load factor at 36*l.* 4*s.* a kilowatt. This gave a difference of 16*l.* 8*s.* a kilowatt in favour of the large station with large units and illustrated how in the general case it should pay a railway company to purchase power from a large power company. When transmission is taken into account, however, it is seen that if a railway has 6,000 kw. of load and there is a 50,000 kw. power company station 20 miles away, the whole of the capital cost saving per unit capacity would be wiped out if three-phase cables at 33,000 volts were used to transmit the energy, and from the capital cost point of view, the railway might just as well build its own 6,000 kw. station.

This example illustrates the importance that transmission problem plays in the whole question and adds interest to the direct current transmission developments to which Mr. Smith gave publicity for the first time. The Thury direct-current system is generally well known, and the Metropolitan Electric Supply Company have an installation in its Southall area which was put in by Mr. J. S. Highfield, and has been in operation for a number of years. The main objections to the Thury system lie in the difficulty in generating high-tension direct-current on a sufficiently large scale, and the large line loss due to the constant current which is a feature of the system. The possibility of direct-current transmission would appear likely to be enormously extended if a new type of machine, which has been named the transverter, proves commercially successful. This has been designed by Mr. Highfield's brother, Mr. W. E. Highfield, in conjunction with Mr. J. E. Calverley, and has been built by the English Electric Company at their Preston works. A machine of 400 kw. and giving 100,000 volts direct-current, has been in experimental and satisfactory operation for some 15 months, and two 1,000 kw. machines are shortly to be put into commercial work.

The transverter consists of a static transformer and a fixed commutator with revolving brush gear, driven by a small motor running in synchronism with the alternating current supply to the primary winding of the transformer. Secondary windings on the transformer connect to the commutator, which converts the alternating current to direct-current. Several groups of secondary windings may be placed on the transformer and by connecting them to commutators connected electrically in series, high pressure direct-current is produced. Each commutator in the machine first made deals with a pressure of the order of 12,500 volts, so that the eight commutators provided give 100,000 volts. The efficiency of conversion or "transversion" in a 2,000 kw. machine is of the order of 95 per cent. Mr. Smith estimates that in the case of the transmission of 25,000 k.w. for railway traction purposes, for a total distance of 50 miles, and using 100,000 volts direct-current and duplicate underground cables with transverter plant, a saving of about 50 per cent. would result, as compared with a three-phase 66,000 volt underground transmission and converter plant. The respective capital costs are 355,000*l.* and 730,000*l.* These figures suggest that a remarkable and very important electrical step forward is possible in the near future.

THE RELATIONS OF THE ELEMENTS.

WHEN the Institute of Metals inaugurated the annual May lecture twelve years ago, metallurgists and other scientists were perturbed by the apparently chaotic state to which the study of radioactivity had reduced the good old theory of the permanent and indivisible atom. Those who heard, on Thursday last week, the twelfth May lecture, which was delivered by Sir Ernest Rutherford on "The Relation of the Elements," were probably ready to admit that order is being evolved from the chaos, and that the coming generation may find the study of physics and chemistry more easy than their fathers did, though the mathematical basis may be more severe.

Sir Ernest briefly reviewed the present way of regarding the problems of the constitution of the atoms and the relation of the elements. The simplicity of that relation, he said, was largely due to the recognition of the atomic nature of electricity. Our idea of the molecular structure of matter depended mainly upon the nature of the atom, and our notion of the nature of the atom depended upon the atomic nature of electricity. Every quantity of electricity, large or small, could be expressed as an integral number of a fundamental unit. About the unit or atom of negative electricity, the electron, we had long been fairly certain. The atom of positive electricity had been a difficulty; but the nuclear atom which we had evolved, was now accepted by all theorists as the basis of the structure of the atom, and it was extraordinarily valuable for explaining the fundamental properties of the atom. We studied that nucleus and determined the charge on it by means of X-rays and the scattering of α-rays with which the nucleus was bombarded—approximately, until Moseley pointed out the extraordinary simple quantitative relation. When the elements were arranged according to their atomic weights, the ordinal number (hydrogen 1, helium 2, lithium 3, . . ., uranium 92) expressed the nuclear charge. The nucleus was surrounded by rotating electrons, and our chief problems were of two kinds: (1) The distribution and motion of the electrons, and (2) the structure of the nucleus.

The solution of the first of these problems appeared impossible, because the rotating electrons should constantly radiate energy, until Bohr showed, by the aid of a special hypothesis of the quantum theory, that the position of the electron was not defined by the older views, but by a quantum relation connected with simple numbers. The problem was even then of enormous complexity. According to the general idea of Bohr the electrons were arranged in groups or shells. There were probably two electrons close to the nucleus; there followed successive groups distinguished as the K, L, M groups, all controlled by the nucleus. The hydrogen atom contained only one electron, the helium atom contained 2, and as the numbers increased (to 92 in the case of uranium) the electrons grouped themselves. That distribution gave us the optical and X-ray spectra; it also explained why, in the periodic table of the elements, we suddenly came to a family of elements (the rare earths) in which the properties changed very slowly. Bohr's theory included that in general additional electrons formed another shell outside the previous shells, but in this case the further electrons went inside; the external shell remained therefore the same for the various elements of the rare earths, and hence the great similarity. It was too early to express any definite opinion; but the success already achieved showed that we were on the true line. There was, further, the rather simpler point of view of Langmuir, who considered the electrons more or less fixed, in certain groups, yet able to oscillate. The view might be useful to chemists, but it was merely descriptive. Sir Ernest did not refer to other hypotheses.

Passing to the second problem, which he mainly wished to discuss, viz., the structure of the nucleus, Sir Ernest Rutherford first pointed out that modern research had crowded the periodical table with radioactive products ranging in their ordinal

numbers from 80 up to 92. All those radioactive transformations,* though highly complex and involving time periods of seconds and of many years, followed really simple laws and were due to changes in the nucleus, and not to changes in the external systems of electrons. The particles expelled were α particles (helium nuclei), β particles (electrons) and γ particles (highly-penetrating X rays). They must all come from the nucleus, and the nuclear charge was thus really the resultant charge, the difference between the positive and the negative units. That nuclear charge might be the same in several bodies, though they differed as to mass or to nuclear arrangement; such bodies were isotopes. Many of the radioactive products were isotopes. The researches of Aston and lately also of Dempster showed that many other elements had isotopes; but no traces of isotopes had been detected in the cases of carbon, oxygen, sulphur and phosphorus. These mass determinations also proved the atomic weights to be integers—approximately, at any rate—as one would expect them to be if the masses were made up of numbers of unit mass.

If, however, hydrogen were to be the unit, as we had reason to believe, radioactive disintegration did not indicate it as such. That disintegration yielded electrons and helium nuclei, which must therefore be constituents of the nuclei of radioactive elements, but never any trace of hydrogen. Yet helium of mass 4 might be a secondary unit, being itself made up of 4 hydrogen units. There was the difficulty that the mass of the hydrogen atom was not exactly 1, but 1·0077 (on the basis oxygen = 16), whilst the mass of the helium atom was exactly 4. But there had been a loss of mass due to the emission of energy in binding the four hydrogen nuclei together with the two electrons required to build up the atom of helium. Sir Ernest turned to the experiments of the last few years† which proved that hydrogen was one of the constituents at any rate of a considerable number of elements studied.

Most of the atoms were very stable; it required attack by the most powerful projectiles at our disposal, swift α rays, to disrupt them. The nuclei of the elements of high ordinal numbers (large mass) seemed to be surrounded by a region of impenetrability, difficult to traverse. Lighter atoms were more easily disrupted. It was not necessary to bombard elementary substances; magnesium oxide would do as well as magnesium, except in so far as the oxygen also attacked would complicate matters.

When now atoms of many elements, including hydrogen itself, were so bombarded, certain particles were set free which travelled on at higher speeds than the bombarding projectile and, striking a screen of zinc sulphide, caused it to scintillate. Magnetic deflections proved those particles to be hydrogen nuclei. Their speeds and the ranges of their movements differed with the speed of the projectile and with the material. The particles ejected from aluminium with almost explosive energy had the maximum range so far observed of over 90 cm. (in air). But not all the elements tried gave hydrogen particles; oxygen and carbon (as such or as CO_2) did not, except in the presence of traces of water vapour. Now the atomic weight of carbon was $12 = 3 \times 4$, that of oxygen $16 = 4 \times 4$; both numbers were exact multiples of 4. On the other hand boron, $11 = 2 \times 4 + 3$, nitrogen $14 = 3 \times 4 + 2$, aluminium $27 = 6 \times 4 + 3$, did liberate hydrogen. The 4 would indicate the presence of a helium nucleus which itself seemed to be extraordinarily stable. The excess over a multiple of 4 would be represented by hydrogen nuclei, and these latter probably formed satellites of the system, more easily dislodged than the core. The conclusion was, then, that the elements were composed of helium nuclei, electrons and hydrogen nuclei, and since helium itself was built up of hydrogen nuclei and electrons, the nuclei of the elements were ultimately ordered structures of these two constituents. But the arrangements of the parts and the laws of the forces were still unknown.

Those views, Sir Ernest concluded, remained speculative. When Moseley brought his momentous communication before the Royal Society in 1914, he (Sir Ernest) was asked about the structure of the nucleus, and he replied: "Leave that to the next generation." But great strides had been made since then, notably by the work of Ellis on γ-rays, and we might yet learn how one element was formed from another.

THE IMMUNITY OF PUBLIC SHIPS.

THE immunity of public ships is to be one of the chief items on the agenda of the conference to be held in London, on October, of the Comité Maritime International. It is understood that this has been arranged at the instance of the Chamber of Shipping of the United Kingdom, but the matter seems to have originated with a formal note addressed by Mr. Justice Hill to the Comité Maritime International in which he invited them to consider the question of the immunities of sovereign states in respect of proceedings against maritime property (ships and cargoes) owned or used by them. In his note, Mr. Justice Hill points out that a British sovereign cannot, against his will, be made subject to the jurisdiction of his own Courts, nor can his property be proceeded against; and this immunity, in compliance with international comity, is extended by the British Courts to foreign sovereign states.

The result is that where ships belonging to sovereign states are involved in collision, or where such ships and state-owned cargoes have salvage services rendered to them, they cannot be arrested or be made the subject of legal proceedings in the ordinary way unless the sovereign state consents. Even as regards ships privately owned, but in the possession or service of a sovereign state, the Courts will not allow them to be arrested, because in this way the sovereign state would be deprived of their use. Several examples are given in the note. The Broadmayne was a British ship in the service of the British Sovereign during the war. The action was for salvage, but all proceedings with a view to the arrest or detention of the ship were stayed so long as the ship should remain under requisition in the service of the Crown. The Messicano was an Italian ship in the service of the Italian Government. It was involved in a collision, and a similar order was made.

The cases instanced by Mr. Justice Hill arose during the war, and the service in which the privately owned ships were engaged was in the nature of war service; but, as he points out, there seems to be nothing in principle to prevent privately owned ships in the service of a sovereign state being immune from arrest in respect of matters arising out of ordinary trade service, although this cannot be treated as settled law. The grave objections to the immunity of such ships from legal proceedings and arrest, at least when they are engaged in times of peace and in trade, are referred to in the note. In one case it was said: "It is a great hardship upon the persons who have claims against such privately owned vessels that they should lose their most substantial remedy (arrest); and, in the interest of safe navigation, it is most unfortunate that there should be a number of vessels navigating the seas whose owners know that however negligently they may be navigated, no maritime lien can be enforced on the vessel while it is in State employment."

Mr. Justice Hill concludes by expressing the opinion that a remedy for the unsatisfactory position at present existing is to be sought on such lines as these: If Sovereign States engage in trade and own trading ships of their own or use trading ships of private persons, they should submit to the ordinary jurisdiction of their own and foreign Courts, and should permit those Courts to exercise that jurisdiction by the ordinary methods of writ and arrest; and it is a matter for consideration whether this should not apply also to state-owned ships not engaged in trade, at least, to the extent of providing some means whereby an undertaking to pay should take the place of arrest and bail. It is satisfactory that these important questions are to be considered by the Comité Maritime International, especially as a Committee was recently appointed by the Lord Chancellor to consider the whole question of civil proceedings by, and against, the British Crown. At present, as has been repeatedly pointed out, in all legal proceedings against the Crown, the dice are seriously loaded against the subject.

THE IRON AND STEEL INSTITUTE.

(*Continued from page* 563.)

IN our last issue we described the opening proceedings of the meeting held on the morning of Thursday, the 4th inst., and gave an abstract of the President's address. We continue our report below.

THE SIEMENS FURNACE.

It had been intended to take two papers on the Thursday morning, but the paper by Mr. Fred. Clements, M.Inst.C.E., on "British Siemens Furnace Practice" proved so interesting that the discussion did not conclude till the time of adjournment. We print an abstract of this important paper on page 579 of this issue.

The discussion was opened by Mr. Saniter, who said that he thought that the author's figures tended to give an exaggerated idea of the drop of the temperature of the chequers in the regenerators; which apparently fell in 5 minutes from 1,480 deg. to 1,200 deg. It should be noted, however, that these temperatures were measured in the uptake flue and not in the regenerator itself. As for the author's thermal balance sheet, it would be seen that Mr. Clements had taken credit for the burning of the carbon to CO only, but in the bath the carbon burnt to CO_2. This correction might perhaps affect the estimate of the radiation losses. As to these, whilst no doubt it would be easy to insulate the roof, the speaker feared that if this were done the wasting away would be quicker. From the author's figures it would appear that at Parkgate the Centigrade heat units required per ton of ingots made was nearly 1,000,000 below the next best result he had been able to record, and some 2,000,000 below the worst. He asked if this remarkable figure was due to the proportioning of the chequers. With regard to the suggested design of furnace he would like to be assured that the regenerators—20 ft. high, and filled with brick, giving openings of 2½ in. by 4 in.—would not affect the "draughting" capacity of the furnace.

Mr. Christmass, who spoke next, said that he had just returned from a five weeks' visit to American steel works. One of the various points of interest was the universal use there of waste heat boilers. He had seen in the United States a glass-melting furnace with a bath 144 ft. long by 35 ft. wide, and this, like 95 per cent. of American steel furnaces, had water-cooled doors, frames and port blocks. The author had laid stress on the importance of making the flame impinge on the bath at the proper angle, but did not say how this was to be maintained. At Gary the water-cooled ports had lasted without replacement for 2,038 heats, so that here, at any rate, the desired angle was maintained. As for the frames and doors the water-cooling made it possible to stand close up to them and the inspection of the roof and the interior of the furnace was correspondingly facilitated. These water-cooled components lasted extremely well, some at Gary having been put in seven years ago, and at the Edgar Thomson furnaces the total cost, including purchase price and maintenance was stated to be but 2½ cents per long ton of steel made. Ordinary doors and frames could not be bought and maintained at this figure. The waste heat boilers attached to a nominal 75-ton furnace with an actual output of 90 tons to 95 tons, yielded 354 h.p., and were said to reduce the net cost of the steel by 50 cents per ton, but in this estimate the first cost was not included. All the steel makers in the United States were abandoning valves in which the direction of the gas or air was bent through 90 deg. as was usual here, and were adopting straight-through valves, the main advantage of which was that there was less loss of pressure.

Dr. McCance said he thought that the author's heat balance required some correction, being, in his opinion, calculated on the wrong basis. The proper plan, he thought, was to determine the heat put into the furnace, and to compare this with the heat that came out. To illustrate his remarks he exhibited the table which we give on the next page.

* We would refer our readers to recent lectures by Sir Ernest Rutherford, reported in our issues of March 10, page 299; March 17, page 331; March 24, page 365; March 31, page 386; April 7, page 414; April 14, page 465; and April 21, page 494.

† Compare ENGINEERING, April 21, page 495 *ante*, for further particulars.

Heat Input.		Heat Output.	
Gas (calorific value)	144·3	Radiation	107·4
Sensible heat ...	19·5	In gas	61·1
Heat in moisture ...	4·6	In steel	46·9
Total heat of pig in bath	21·6	In slag	11·6
Oxidation of carbon to CO	5·2	In reduction of Fe_3O_4	2·7
Oxidation of manganese	1·6	In reduction of lime	5·3
Oxidation of silicon	1·3		
Oxidation of phosphorous	7·3		
Oxidation of slag ...	3·2		
Total heat input in millions of C.H.U. units ...	209·0	Total heat accounted for in millions of C.H.U. ...	235·0

There would thus appear to be something wrong with Mr. Clements' balance sheet, which the speaker suggested was due to the observations being made whilst heat was being largely absorbed by the bath. The radiation losses had perhaps been over-estimated accordingly. Taking these as 81·4 instead of 107·4, the two sides of the balance sheet would agree. As to the question of efficiency, it must be remembered that the steel had not merely to be melted, but refined and cast, and the superheat necessary to permit of the latter operation was unavoidable. Similarly the slag had to be hotter than was theoretically necessary. The heat expended in reducing the iron oxide and lime was also unavoidable, so that the heat usefully employed was the sum of the last four items in the right-hand column of the above table. On this basis the furnace efficiency was 32·3 per cent., which the speaker thought represented the facts more accurately than the author's estimate.

Dr. Harbord, who followed, said that accepting the author's figures, the serious losses in the operation of a Siemens furnace were those from radiation, and from the heat carried off by the escaping gases. The reduction of the radiation losses was a very difficult problem, as if the roof were insulated there was a danger of melting it down, whilst if water-cooling were resorted to, there was a loss of heat. Hence unless better refractories could be found the radiation loss from the bath could not well be reduced. In the case of the regenerators the problem was easier. As for the loss in the escaping gases, the only way of making a large diminution in this, would be to decrease the volume, as only minor gains could be made by better regulation. Hence he did not think that much could be done unless we could get cheaper supplies of oxygen, and thus reduce the amount of the inert nitrogen. He recognised that this procedure might be impracticable without better refractories, and there might also be trouble from oxidation, but from the point of view of saving heat the plan would help.

Mr. Talbot said that as a practical man vitally interested in the question of costs, he was much struck with the author's claim that the furnace described in the paper could be run with 3 cwt. of coal per ton, and that this figure might even be reduced. He did not, however, see how such results could be attained in overall practice; when allowance was made for the week-end break. He thought that the author's design of furnace was a very good one, but with regard to the regenerators it must be borne in mind that they had to deal with dirty gas, and with such a depth of chequers, practical difficulties might arise.

Mr. Smeaton, who followed, said that the paper discussed merely modifications of ancient designs, but that in his opinion what was required was an entirely new departure. He claimed that, he could in this way reduce present overall consumptions by 40 per cent.

Mr. H. M. Ridge said that the paper was so important that he hoped arrangements would be made for its further discussion. Investigations, such as the author's, were sometimes looked on as of merely theoretical interest; but it had always been found that when similar studies were made in steel works, useful results were obtained and costs reduced. Some years ago he had himself remodelled a furnace reducing the fuel consumption in the ratio of 85 to 155 for the same output. He noted from the author's figures that during the melting the CO_2 in the waste gases was reduced. This was undesirable and meant a considerable loss of heat in each run. He suggested that although the author had provided large slag pockets in his proposed plant, that further steps would be required to prevent slag entering the regenerators and destroying the brickwork. He also asked whether these chambers would not be difficult and expensive to repair. He questioned, moreover, whether, with a gas velocity of 20 ft. per second at the top of the regenerators, the gas would be effectively heated. As for water cooling, he was not himself in favour of it.

Dr. Hatfield, who followed, said that he thought the author's estimate of furnace efficiency as some 17 per cent. was nearer the mark than Dr. McCance's estimate of nearly 33 per cent. For his own part he estimated the theoretical value of the coal required as 1 cwt., and if they added to the author's 4½ cwt. of coal the amount required to produce the heat carried into the furnace by the molten pig-iron, they would get a total figure of about 6½ cwt., from which the efficiency came out as some 17 per cent. to 18 per cent. It was a useful fact to have on record that the coal consumption had been reduced at Parkgate to 4½ cwt., and if the author succeeded in working his new furnace with 3 cwt. it would be a very remarkable result. As for water cooling there would be no difficulty in fitting it to the furnace later on, should this appear desirable. He thought that the furnace roof might be insulated with 2 ft. of sand, which might perhaps be made practicable by strengthening the refractories now used, and would lead to higher efficiencies.

Dr. Rosenhain, the next speaker, said that there appeared to be a fundamental misconception in regard to the endurance of refractories. The temperature of a refractory was governed by the balance between the heat received and the heat radiated away. If the heat supply were reduced, the temperature of an insulated refractory need not be higher than that of an uninsulated one, and it would neither waste not melt.

Mr. Whitfield drew attention to the fact that the temperature of a flame yielding CO_2 was lower than the calculated value. In one plant with which he had been connected the flue gases were found to have a temperature of 600 deg. to 700 deg., and caused trouble. The length of the regenerators was accordingly increased by 30 per cent. to 40 per cent., with great benefit, and the furnace worked better. He thought that the regenerators proposed by the author would prove more satisfactory if made less deep, but longer.

The president in adjourning the meeting stated that the council proposed to arrange for a further discussion of Mr. Clements' paper at some provincial centre.

The Effect of Oxidising Gases on Heated Iron.

The first paper taken when the meeting was resumed in the afternoon was one by Professor H. C. H. Carpenter, F.R.S., and Miss C. F. Elam, on the effect of oxidising gases at low pressures on heated iron. We reprint this paper in full on page 605 of this issue so that it is unnecessary to refer here to the nature of its contents.

After the principal points of the paper had been explained by Professor Carpenter, the discussion was opened by Dr. C. H. Desch, who remarked that the paper was of a very interesting and novel nature. He suggested, however, that the 61·2 per cent. of hydrogen sulphide and sulphur dioxide was really all sulphur dioxide, as it was difficult to imagine these two gases existing together. The speaker also expressed doubt of the author's explanation of the parallel growth by crystallisation. The temperature he said was not high enough for the volatilisation of the carbon and there was no solvent present. In all such cases the substance forming parallel growths must be deposited from liquids or vapours. He suggested as another explanation that the crystals formed were pseudomorphs of iron rather than parallel growths of crystals, and mentioned that the microphotographs reproduced in the paper strongly resembled some by Dr. Stead of deeply etched structures. If the iron in the process of oxidation kept its orientation and had the structure developed in that way, some such result would be obtained as was shown by the author. On the other hand it was very difficult to imagine how the oxide could be formed in a crystalline manner without the presence of any solvent or without the existence of a vapour phase.

The next speaker, Colonel N. T. Belaiew, said he wished to endorse Dr. Desch's remarks that the observations described in the paper were very interesting and novel. He thought they were also very important, in that they appeared to provide a new method for determining the structure of iron in the high temperature area. What was going on in that area, he added, was still somewhat uncertain. The speaker, however, wished to support Professor Carpenter's views as to the explanation of the phenomena, and thought it quite possible for the formation of oxide to proceed on the lines indicated. Some observations of Osmond, he said, tended to show the same thing. As to whether the layers observed by the authors were due to oxidation of the iron or not, it appeared to the speaker that they could not be iron, and if not the alternative was that they were oxides. Professor Carpenter had stated that Fe_3O_4 was first produced, and that the orientation was that of alpha iron. From the crystallography of alpha iron it was known to have a cubic structure and magnetite generally crystallised in the octahedral form. Slight differences in the conditions, however, modified the cubic system, and it could also be obtained in cubic and various dendritic forms. Under the conditions described the speaker said the crystallisation of magnetite would follow the lines of crystallisation of alpha iron. With regard to the small triangular figures shown in the microphotographs reproduced in the paper in Figs. 5 and 6, the speaker thought that these indicated that we had not to deal with cubic but with octahedral crystals. It was difficult to say why this was so, but a possible explanation was that the magnification was greater in these illustrations than in others; the time of annealing was also longer. The speaker also suggested that the influence of the gamma iron might have manifested itself in producing these figures.

Dr. W. H. Hatfield, the only other speaker on this paper, said that the phenomena were astonishing, but he accepted the authors' explanation of them. He added that Professor Carpenter and Miss Elam had contributed papers of fundamental importance on the subject of aluminium crystals to other institutions and suggested that such papers might well be brought before the Iron and Steel Institute. To this the chairman remarked that the suggestion would receive due consideration.

Miss Elam then replied to the discussion, first explaining that the gas analysis given in the paper had been carried out in the fuel department of the Imperial College, and although it was difficult to understand the existence of hydrogen sulphide and sulphur dioxide together, they had been assured that this was the case. With regard to Dr. Desch's suggested alternative explanation that the facets were due to oxidation of the metal rather than to growth on the iron, the reason they had suggested the latter explanation was that if it were merely oxidation they could not understand why it should go on growing in the same form either in the alpha or the gamma range. The iron, the speaker remarked, could be heated and cooled through those ranges four or five times without producing any change. Another reason for doubting the explanation of oxidation was the formation of small crystals which could not be photographed but could be examined under the microscope by continually adjusting the focus. These, the speaker remarked, could not be explained as oxidation. She had been interested in Colonel Belaiew's remarks, but had no evidence that magnetite had been formed. When examined, the oxide had been found to be non-magnetic and the reason for suggesting magnetite was that it belonged to the cubic system. With regard to the triangles formed in the microphotographs referred to, the speaker remarked that these had been found in other specimens heated for a shorter period, and also in some heated only in the alpha range.

Hydrogen Decarburisation of Carbon Steels.

The next paper taken was that by Mr. C. R. Austin, dealing with the hydrogen decarburisation of carbon steels and containing some considerations on related phenomena. The paper describes a short

investigation into the removal of carbon from certain fairly pure carbon steels by means of hydrogen at normal pressures and at varying temperatures, and deals with its effect on the configuration of the crystallisation in the decarburised areas. It also deals with the phenomenon of the diffusion of carbon in iron. Three commercial carbon steels were employed containing 0·40 per cent., 0·99 per cent. and 1·27 per cent. of carbon, and having 0·60 per cent., 0·61 per cent. and 0·42 per cent. of manganese, respectively. Silicon, sulphur and phosphorus were present in small quantities, so that, with the exception of the manganese content, the steels may be regarded as of a fairly high degree of purity. The specimens were heated in an electric tubular furnace, through which hydrogen could be passed, and temperatures were measured by a thermo-couple inside the tube. The paper gives an account of the influence of time and temperature on the rate of decarburisation, and on the configuration of the recrystallised ferrite grains constituting the decarburised portions. It shows how the initial carbon content of the steel affects the configuration of the crystal grains comprising the hydrogen decarburised material when the removal of the carbon is effected at a sub-eutectoid temperature. Experimental consideration is also given to the effect of temperature on the rate of diffusion of carbon, or of carbide of iron, in iron; in all instances the medium employed was a partially decarburised hyper-eutectoid steel presenting a microstructure consisting of a completely decarburised peripheral zone surrounding an apparently unaltered core. The conclusion is that alpha iron must have a real solubility for carbon or carbide of iron and that the degree of solubility depends on the temperature. Decarburisation by means of pure dry hydrogen has been compared with the results obtained with moist commercial gas, and it is demonstrated that the presence of oxygen is not essential for the production of the columnar feature of the crystal grains. The salient features of the decarburisation effected during the maintenance of a temperature gradient along the specimen are also recorded.

After Mr. Austin had read his paper in abstract the secretary read an abstract of a paper by Mr. F. W. Ehn who was unable to be present, and the chairman suggested that the two papers should be subsequently discussed together.

Influence of Dissolved Oxides on Carburising and Hardening Qualities of Steel.

Mr. Ehn's paper, which we hope to reprint in a later issue, showed that the results obtained in commercial carburising are largely dependent on the quality of the steel, and as these qualities cannot be determined by the usual chemical and physical tests, it renders obvious the practical value of a carburising test. The paper may be summarised as follows: Failure in case-hardening, especially as regards soft spots, is often due to improper steel. Variation of structure of a carburised piece, gives a direct indication as to whether the steel is suitable for carburising or not. Coarse-grained structure in case and core of carburised steel, with large crystals of pearlite and clean cut cementite areas in the hypereutectoid zone, are signs of good, or normal, steel. Proof is given that oxides uniformly distributed through the steel are the cause of the different carburising properties, and the influence of oxides is explained theoretically. Suggestions for new specifications for steel for ordinary carburising purposes are given.

The first speaker in the discussion on these two papers was Mr. E. H. Saniter, who remarked, with reference to Mr. Ehn's paper, that the author appeared to have convinced himself that troubles in case-hardening were due to certain causes. In the speaker's opinion, however, the author had not proved his case. The paper stated that the steels employed contained from 0·005 per cent. to 0·010 per cent. of silicon, and the speaker stated that all steels with such low silicon contents were oxidised. The trouble, he said, was due to this oxidation. The microphotographs reproduced in the paper, he remarked, were very interesting, and he inquired what was meant by S.A.E. 1020 steel mentioned in the paper.

Colonel Belaiew, who followed, also referred first to Mr. Ehn's paper and remarked that the explanation of the cause of the difference in grain size given by Professor E. D. Campbell in a letter quoted in the paper was incorrect. The letter suggested that the diminution in grain size was due to the increase in the number of centres of crystallisation arising from the presence of impurities, but the speaker did not think it could be explained in this way since the effect depended on conditions subsequent to those mentioned in the correspondence. He did not think that slag enclosures could influence the size of the grains. With reference to Mr. Austin's paper, the speaker had been interested to read that Roberts-Austen had recorded a statement of Chernoff to the effect that two surfaces of iron of the same nature, if placed in intimate contact and heated to about 650 deg. C., would unite. The name, he said should be spelt Tsernoff, and he added that Professor Tsernoff had attached considerable importance to the phenomenon and had endeavoured to explain it in the most plausible manner.

The next speaker, Dr. W. Rosenhain, alluding to Mr. Austin's paper, said that decarburisation of steel at high temperatures was very important and interesting because, when studying the behaviour of steel at high temperatures, decarburisation was one of the greatest troubles encountered. Apparently, he remarked, decarburisation occurred in any case unless carbon were present in the atmosphere of the furnace. He added that he had found it with an atmosphere of nitrogen, but it could be prevented by the introduction of hydrocarbon vapours. The speaker thought that Mr. Austin's evidence that moisture played no part was not quite complete. The only method of eliminating oxygen, the speaker stated, was to pass the gas through a tube containing copper heated to 800 deg. or 900 deg. C., but the removal of the last traces was a very difficult matter, and a little oxygen went a long way; it acted as a carrier of carbon. With regard to the diffusion of carbon in iron below the critical point, the speaker questioned the author's conclusion that alpha iron must have a real solubility for carbon, and said he was inclined to think that the explanation must be looked for elsewhere. It was, he said, closely associated with crystal boundaries. On Mr. Ehn's paper the speaker remarked that the difficulties in connection with case-hardening were well known. The author, he said, had shown a definite connection between case-hardening properties and microstructure, but whether or not the structure was due to oxides had not been established; in this respect the speaker agreed with Mr. Saniter. The correlation of microstructure with hardening difficulties, however, was very interesing and was a step towards the elucidation of the problems involved.

On Mr. Austin's paper, Dr. D. Hanson remarked that one of the microphotographs given as evidence of the solution of carbon in iron below the critical point appeared to contain pearlite, and pointed out that the diffusion of carbon in ferrite could not produce pearlite, which was produced as the steel cooled through the critical point. More explanation of the microphotograph, the speaker said, was necessary. He suggested, however, that the temperature had risen above the critical point and fallen again; this, he said, would provide a complete explanation.

Dr. Hatfield, who followed, also agreed with Dr. Hanson, that it was not possible for diffusion to occur to the extent indicated. With regard to Mr. Ehn's paper, he remarked that experimental evidence for the conclusions given was not contained in the paper. As to the first conclusion that soft spots were due to oxide, the speaker said that this was not the case; they were due to indifferent hardening.

Mr. J. N. Greenwood also spoke on Mr. Austin's paper, but remarked that as his complete observations would be rather lengthy, he would communicate them in writing. At the conclusion of Mr. Greenwood's remarks the chairman intimated that Mr. Austin would prefer to reply to the discussion on his paper in a written communication. The meeting was then adjourned until the following morning.

The Annual Dinner.

The dinner of the Institute took place at the Connaught Rooms in the evening, amongst the guests being Lord Inchcape, Sir Eric Geddes, Mr. Tokugawa, the Japanese *Charge d'Affaires*, and the Right Hon. E. Shortt. Sir William H. Ellis (vice-president) said the Institute extended the warmest welcome to these and other guests including the French metallurgists and representatives of kindred societies then present. Lord Inchcape, in proposing the "Iron and Steel Institute," said the shipping trade with which he was identified and the steel trades were most intimately connected, that he saw indications of improvement in business all round, but in order to take advantage of such a state of affairs there must be industrial peace at home and much greater economy on the part of the Government. The president (Mr. Francis Samuelson) replying, said he was proud that the Institute had maintained its membership in spite of the necessary advance of 50 per cent. in the subscription; 25 per cent. of the members were other than British subjects and the Institute thought it received more than it gave by having foreign members, good fellowship amongst the nations being thereby promoted.

Carnegie Research Scholarships.

At the meeting of the Iron and Steel Institute on Friday morning, the 5th inst., the secretary read the list of the Carnegie awards which was as follows:—

Grants of 100*l.* apiece were awarded to: Dr. Arthur Bramley, to assist in studying the carburising and decarburising effect of different gases on iron and steel; to Mr. A. L. Curtis, to carry on researches in steel moulding sands and their behaviour under high temperatures; to Mr. O. W. Ellis, lecturer in metallography at the University of Toronto, for studies in the effect of constitution on the malleability of iron and steel at high temperatures; to Dr. J. Newton Friend, Lecturer at the Birmingham Technical School, to continue his corrosion tests on a large scale; to Mr. A. M. Parkin, of Sheffield University, for studies in the metallurgy of tungsten; to Mr. G. Phragmen, of Stockholm, to study the specific weight of molten metals, by a new method; and to Mr. W. E. Williams, to study the application of X-ray spectrography to the examination of the structure of steel.

Blast Furnace Filling.

The President then called on Mr. D. E. Roberts, M.Inst.C.E., to read his paper entitled "Notes on Blast Furnace Filling." This paper is reprinted on page 599 of to-day's issue of Engineering.

The discussion was opened by Mr. Reece, who said that the author had raised a highly contentious point as to the respective merits of bucket and skip feeding of blast furnaces. There was no doubt that both systems could be made to work satisfactorily, but satisfactory working was not the only point involved. We had in the first place the question of costs, and the speaker thought that it would generally be conceded that on this head the advantage lay with the skip. The bucket system of charging furnaces involved very massive and costly structural work, whilst light structures sufficed for the skip. The question of the even distribution of the charge was of great importance, and admittedly the bucket gave a good distribution, but there was no question but that equally satisfactory results could be secured with skips. In fact, with revolving tops the uniformity of the distribution of the charge was as good as with hand filling. No doubt the revolving top implied some mechanical complication, and objection was taken to the placing of such mechanism at the top of a blast furnace. But with modern furnaces the top was cool, and there was moreover nothing there to damage or injure the mechanism, which, in his opinion, was in fact less subject to injury and wear, than if it were situated in the dust and dirt of the stockhouse, as was necessary with the bucket method of filling. Another important factor was flexibility. This was not as easily secured with the large and slowly operated buckets as with the light and quickly moving skips. A furnace might be designed for charges of 2½ units, but the designed figure was at best an approximate one, and it might become desirable to alter the coke unit for a time, say from 2½ tons to 5 tons. With the bucket system it was only possible to provide for this by reducing the efficiency of the plant. Mr. Roberts suggested that the difficulty might be met by putting two

charges in the bucket, but this might require a total load of 14 tons. The bucket system was in fact too rigid. As for the question of wear and tear, it was often said that owing to the higher speed this must be more serious with the skip system, but modern engineers had no difficulty in running machinery at high speeds without excessive wear. The points in favour of the skip were its lower cost, lighter construction and greater flexibility, whilst the sole advantage of the bucket was that in cases in which the coke ovens were sufficiently near the furnace, the coke could be loaded into the bucket at the ovens without transfer to bunkers. The speaker also thought that the direct diagonal path which the skip traversed from the ground to the furnace top was a neater and better arrangement than that in which a bucket was first hoisted vertically, then traversed horizontally and finally lowered vertically again, though he admitted that there were cases where this plan might be a useful makeshift in the reconstruction of existing works. In the early days it was true that the skip plan had encountered great difficulties, being often characterised by segregation of the materials and bad distribution. The means of overcoming this drawback had, however, been sought out and perfected, but the bucket system had benefitted by the bad name that the skip had acquired in the early days of its development. The whole trouble had, however, been solved by the adoption of the revolving hopper, and the skip was now coming into its own.

Mr. Lee, who spoke next, said he thought that there might be trouble with dust in the underground chamber for charging the bucket shown in the author's diagram, Fig. 17, particularly with calcined ore. He knew of a similar case in which it had been found necessary to instal a dust collector in order to make it possible for the men to work in such conditions. Mr. Reece had mentioned the advantage the bucket system possessed in the possibility of charging the coke directly from the ovens, but the matter did not end there. The less coke was handled, the better, and the buckets could be charged directly from wagons, and this was most important where the coke was friable. As regards cost he thought that where the bucket could be arranged to feed two furnaces it would not be more expensive than two skip plants.

Mr. F. Clements said that he was opposed to the bucket system which was a Continental development, whilst the skip was essentially American. He did not quite agree with Mr. Roberts' view that the ideal method was hand charging but would accept it as a provisional standard. With bucket charging the revolving necessary to secure even distribution must be done by the man below, who often had to work in a pit dripping with water and smelling like a cesspool. This man made or marred the distribution of the charge, and the conditions in which he worked were not favourable to efficiency. He thought that there were only two skip gears requiring notice, viz., the McKie gear and the speaker's own. The McKie gear had been developed to suit American conditions, where the material charged was very uniform, so much so that the claim had been made that it would not matter if the revolving top went wrong. In England we had to deal with very variable material, the ore ranging in size from lumps as large as one's head to smalls, and with such material he felt confident that the McKie gear would not prove satisfactory. It was to meet these conditions that the large bucket and stock house were introduced, but it would be wrong to assume that perfect uniformity was thus secured. In the speaker's own gear the shovel effect, to which Mr. Roberts referred in his paper, had been overcome and a distribution equal to hand filling was secured. The man in charge had an indicator which showed him exactly how the furnace was operating and where adjustments were required. He believed that the balance of advantage was with the skip gear, and thought the author would agree if he examined a really up-to-date skip plant.

Mr. Harrison said that at present there was an enormous difference of opinion as to the relative merits of the skip and the bucket. In adopting any mechanical device at a blast furnace it was essential that the results obtained should be at least as good as could be obtained by hand. Hence anything that militated against good distribution was a disadvantage, and the system which gave the best distribution was that which would win the day. Again, the system that increased the breakage of coke would not be adopted, and the skip was worse in this regard than the bucket. It would be well to remove from coke before charging the smalls due to breakage, which should be used elsewhere than in the blast furnace. He himself would go further and take out also the fine ore. It was not, he thought, worth while to put in mechanical charging gear for old plants, so many compromises were then necessary that a satisfactory job was impossible. It would be far better to put in an entirely new plant. Further it was essential in installing such mechanism that it should dominate the position and take the setting of the pace out of the hands of the workmen.

In reply Mr. Roberts said that he would deal in writing with most of the points raised, but in the meantime would point out that though America was the home of the skip where it was installed at 230 furnaces, in recent constructions the bucket had also been largely adopted and was at present in use at 33 or 34 furnaces. Indeed, Mr. Williams, of the Carnegie plant, had said that he would instal nothing but buckets.

(To be continued.)

THE INQUIRY INTO THE ENGINEERING DISPUTE.

SIR WILLIAM MACKENZIE'S report on the causes and circumstances of the Engineering Dispute was published late on Wednesday night. Before dealing with this report it may be permissible to explain the lines on which the different parties to the Inquiry presented their respective cases. Sir Allan Smith, for the employers, having regard to the fact that the Court was appointed merely to enquire into the causes and circumstances of the dispute, and to report thereon, confined himself to an effort to place before the Court as clearly and succinctly as possible the causes and circumstances of the dispute. He maintained that the Court was not in the position of an arbitrator, and had no power to decide on the merits of the parties' claims. His case was that the Amalgamated Engineering Union had claimed that no overtime should be worked unless with the prior consent of the Union; that this had raised the question of the employers' rights of management of their factories; that in the memorandum of November, 1921, the Union had agreed (*a*) not to interfere with the right of the employers to manage their establishments; (*b*) that instructions of the management should be observed pending any question in connection therewith being discussed in accordance with the regular procedure; and (*c*) that this should apply to the working of overtime; that, on a ballot, the members of the Union had rejected the recommendation of their Executive Council, and that this had led to their being locked out. In accordance with his view of the limitations of the Court's jurisdiction and functions, Sir Allan Smith refrained from discussing the rights and wrongs of the issue which was thus raised. As regards the other Unions, he maintained that in view of the rejection by the members of the Amalgamated Engineering Union of the November memorandum it became necessary for the employers to know the attitude of the other Unions on the important question of managerial rights, and that their action in calling upon these Unions to define their position was justified both at the time and in the result.

Mr. Brownlie essayed the task of justifying his members in their rejection of the recommendations to which he and his Executive Council had been a party. He maintained that as a result of the war, a great change had come over the mind and outlook of the workpeople, and they were no longer going to tolerate the condition of affairs which obtained in the workshops of this country prior to the war, and he left it to be inferred that this justified his members in the action which they had taken. The other Unions maintained that they had no quarrel with the employers; but when they were pressed to say why they would not agree to the terms of the memorandum of November, 1921, so far as it related to the employers' rights of management, it appeared that their position was substantially that of the Amalgamated Engineering Union, viz., that they were not prepared to allow the employers, in the course of the management of their factories, to introduce any change in working conditions which they might consider material, without their prior consent. Sir Allan Smith illustrated the difficulty which might occur under such a state of affairs by asking what was to happen when an employer proceeded to man a new type of machine. If he wished to put a skilled man on to the machine, the unskilled Unions might refuse to consent; and if he wished to put on an unskilled or a semi-skilled man, the skilled Unions might refuse to consent. This was left unanswered.

In the course of the proceedings a good deal of interesting information was elicited from one of the witnesses for the Amalgamated Engineering Union with regard to the method in which the ballot of the Union's members was taken. It appeared that the ballots of the Union are taken, as a rule, at meetings of the branches; that the average attendance at a branch meeting is about one half of the membership of the branch; that, indeed, the branches have not accommodation for all their members on one and the same night, and as a result it is impossible for all the members to take part in a ballot taken in this way; and that on the occasion of the ballot on the Memorandum of November, 1921, ballot papers were issued for about only 60 per cent. of the total membership of the Union. The Executive Council had power to take a postal vote, *i.e.*, to post ballot papers to all the members, but that is done only on rare occasions, and was not done on the occasion in question. The Unions maintained that their methods of taking ballots were a matter for themselves alone, but it seems unfortunate that in this ballot, which the Amalgamated Engineering Union must have known might result in a national lock-out, the Union did not take every step possible to ascertain the views of all its members.

The report of Sir William Mackenzie actually leaves matters much where they were, for it practically points out that no hard-and-fast agreement can be made to cover the issues involved. The question of management of a business is a difficult and responsible task, says Sir William, and no individual workman or trade union official should unnecessarily or without good cause add to its anxieties. On the other hand the employers should recognise that the workman in his more restricted sphere considered vital principles at stake upon which consultation was the only reasonable course of procedure. We do not doubt that the employers will be willing to concede the latter point. The main point of Sir William's report is that settlement of the question of management is a matter of good sense and goodwill between the two parties. On the matter of overtime Sir William considered that the management alone, being possessed of a knowledge of the requirements, were in a position to judge whether this were necessary or not. The National Agreement allows 30 hours' overtime in four weeks, and up to that limit it is stated there must be perfect freedom. Beyond that limit it is stated that it would be open to the suggestion of being unreasonable. It is suggested that time should be given to the employees to consider proposed changes in shop organisation, &c., with the opportunity for discussion between employers and staff before their introduction, and if the discussion should not result in agreement the employers should have the right to put their proposals in force pending a settlement which should have retrospective effect. Sir William, it is satisfactory to note, remarks upon the evident genuineness of the desire of all parties to bring about a solution of the present difficulty.

NOTES.

EXTENSION OF THE RALEIGH CYCLE WORKS.

To mark the completion of their new motor cycle factory, the Raleigh Cycle Company, Limited, invited a party of about 200 guests to visit their works at Lenton, near Nottingham, on Friday last, a special train being run to and from London for

the occasion. Owing to the unavoidable absence of the Lord Chancellor, the new extension was declared open by Mr. W. C. Bridgeman, M.P., the Secretary of State for Mines, who, in an excellent speech, called on the men of goodwill, both among employers and employed, to assert themselves and restrain the minority of mischief-makers and extremists in their respective parties. The chairman and managing director of the company, Sir Harold Bowden, Bart., who presided at the luncheon, stated that the Raleigh factory now covered 11 acres of land and had a yearly capacity of 100,000 push cycles, 10,000 motor cycles, 250,000 three-speed gears and 50,000 motor-cycle gears per annum. At the present time it was extremely busy, particularly in the motor-cycle department. The firm had found themselves faced with serious competition by the Germans who were driving them out of foreign markets by selling machines there at about half the Raleigh price. He had therefore imported one of these machines, and put the position fully and frankly before the workpeople and their responsible leaders. The workmen agreed to the necessity of a reduction in labour costs, and the firm decided to reduce their profits by 50 per cent. with the result that the selling price of a bicycle was reduced from 14 to 10 guineas. An enormous increase in business was experienced and the workmen were kept employed. The production of their 2·75 h.p. motor cycle at 68*l.* had brought them more orders than they could comfortably cope with. The visitors afterwards made a rather hurried tour through the works and inspected the various processes, including tube-making. In the motor-cycle engine-testing department, every engine is tested by a Froude dynamometer, and it is interesting to note that the flat twin engine, rated at $\frac{5}{8}$ h.p., develops on an average 13·9 h.p. at 3,400 revolutions, while the 2·75 h.p. single-cylinder engine develops 6·5 h.p. at 3,000 revolutions. The works are driven by gas engines aggregating 2,640 b.h.p., working on producer gas, and the same gas is also used for heating operations, including the firing of the hardening furnaces, enamelling stoves, &c. The factory is almost exclusively of the single storey, saw-tooth roof construction, and the accommodation for the workpeople, mess-rooms, &c., shows a practical effort to provide good working conditions. The whole of the work is done on a "straight" piecework system.

Alcohol as a Motor Fuel.

The Empire Motor Fuels Committee of the Imperial Motor Transport Council has just published an interim report outlining the researches carried out by the Engineering Sub-Committee into the behaviour of alcohol as a motor fuel. As alcohol of 95 per cent. absolute strength by volume was the strongest that could be produced commercially, this was the fuel used, and the Government allowed it to be employed without denaturing so that the experimental results should not be vitiated by the presence of denaturants. The experiments were divided into four series, covering all practicable ranges of mixture strength, piston-speed, compression ratio and temperature. Subsequent experiments were carried out with 90 per cent. and 99 per cent. alcohol. The conclusions of the sub-committee, of which Dr. W. R. Ormandy is chairman, generally confirm what has been found by other experimenters with regard to alcohol fuel, namely, that the thermal efficiency obtainable with alcohol is higher at all compression ratios than with either petrol or benzol. It is considered that the following points have been definitely proved: (1) That alcohol can be employed from the low compression employed on paraffin engines up to a far higher compression than can be used on any petrol; (2) that the thermal efficiency obtainable with alcohol is higher than with petrol or benzol; (3) that under all conditions of throttle or mixture alcohol requires the spark more advanced than is the case with petrol or benzol and much more advanced with the weak mixtures; (4) that there was no evidence at any piston speed attained in the engine that the rate of combustion of alcohol under the conditions obtaining was too slow to obtain the maximum effect; (5) that detonation does not occur at compressions up to 8—1, and pre-ignition does not occur at 6—1, even when running for long periods at the highest possible power output of the engine; (6) that there were no evidences whatever of corrosion in the engine; (7) that the power output and efficiency are increased by low temperature of the circulating water; (8) that supplying heat to the carburettor reduced the power output but slightly increased the thermal efficiency; (9) that increase in the water contents up to 10 volumes per cent. is an advantage, particularly in very high compression engines. The experiments were carried out on a single cylinder variable compression Ricardo experimental engine, kindly put at the disposal of the committee by the Anglo-Asiatic Petroleum Company, and were assisted by a grant from the Department of Scientific and Industrial Research.

The Resonance Theory, Audition and Colour Vision.

According to the resonance theory of Helmholtz something in our ear is capable of vibrating in response to the acoustic vibrations reaching the ear. The so-called Corti arches (about 3,000) were first supposed to be those vibrators; then it was the basilar membranes, believed to act like harp strings. But our ear is a wonderfully perfect organ. The range of audibility extends over 11 octaves, 7 of which are musical. The sensitiveness diminishes when the notes are very high or low; in the middle of the range, however, we can distinguish two successive notes differing by as little as one-twentieth of a semitone, and we hear, moreover, C and G separately when sounded simultaneously, and not the intermediate E. Otherwise we could not enjoy an orchestral concert. If each vibrator were only to respond to one pitch or even to a series of pitches, we should need thousands of vibrators. Dealing with this difficulty of the resonance theory and confining himself to mechanical analogues, Professor E. H. Barton, F.R.S., of University College, Nottingham, showed in two lectures, delivered at the Royal Institution on the Thursdays of the last two weeks, that a few vibrators or responders, about a dozen to the octave, would suffice for the "Resonance Theory of Audition." In the acoustic experiments Professor Barton suspends, from a long cord, a short heavy pendulum (the driver), and some feet away from the driver, further a series of light pendulums, corresponding in their lengths to the notes and semi-notes of an octave. The little pendulums are simply small paper cones, hanging by plain threads. Sometimes two cords are associated by being connected near the one end by a short bridge-piece. When forced simple or complex vibrations are imparted to the driver by the hand, some of the little pendulums (the responders) will swing in resonance, faintly or strongly. The pendulums are damped by placing rings of copper wire over the cones. When the cones are not damped, the response is strong, but limited by sharp tuning; when they are strongly damped, the response covers a wide range, even with mistuning. The oscillations of the pendulums are photographically reproduced, and these studies prove that a hundred responders in our ear, suitably damped, would suffice to enable our ear to pick up the most complex sounds, and that the number of nerve fibres may, in any case, be much smaller than that of the Corti arches. The resonance theory remains controversial, Professor Barton remarked, but the success realised justified his trying to extend the investigation to a "Syntonic Hypothesis of Colour Vision," the subject of the second lecture. Our eye, it is well known, is much less perfect than the ear. The visible vibration range of the spectrum barely extends over one octave; our eye does not know whether a green is a pure or a mixed colour, it cannot distinguish between summation colours (mixed pigments) and abstraction colours (superposed spectra), and artists cannot predict what colour effect a close interweaving of fine, coloured threads will produce, although the best eye does not distinguish more than 27 colours. But the three-colour vision theory of Young-Helmholtz, so far as it goes, can account for a good deal, and Professor Barton showed that three damped pendulums, corresponding to red, green and violet, and analogous to the C sharp, F sharp and B of the musical scale, would suffice to produce most of all the known shades of colour and account for the facts of colour mixing. The driver would represent the light source; the responders would be some kind of Planck resonators in our retina; the resonators would stimulate some physiological or chemical process, and that took time, about 0·1 second both for the excitation and for the dying-away of the sensation. In colour-blind people certain resonators would be absent. Professor Barton did not claim that the resonators postulated were proved to exist; if some such mechanism were present, however, colour vision should be as it now is.

The White Star Liner "Majestic."

In view of the general tendency of post-war shipbuilding, we imagine that several years will elapse before the claim made for the R.M.S. Majestic that she is the world's largest and most luxurious passenger liner is seriously challenged. By the courtesy of the managers of the White Star Line, we were given an opportunity of inspecting the vessel at Southampton on Saturday last, and although this inspection was necessarily of a somewhat cursory nature, it was fully sufficient to confirm all claims as to her appointments. The Majestic has a length over all of 956 ft. and a breadth of 100 ft., while the height from keel to boat-deck is 102 ft.; her gross tonnage is about 56,000 and her displacement 64,000 tons when loaded to her marks. There are nine decks in all, of which five are steel decks extending for the whole length of the ship, while the remainder are steel-plated erection decks covering not less than half the total length. In keeping with the main dimensions of the vessel, the public rooms are exceptionally large and lofty, and the decorations and furniture, which we cannot describe in detail, are generally elegant and comfortable. The arrangement of the rooms, it may be mentioned, has been materially facilitated by the fact that the boiler uptakes are each divided into two parts athwartships, the two parts being united above the boat deck level and connected with the funnel. The principal public rooms on the promenade deck are the lounge, palm court, restaurant and smoking room, but a drawing room, reading and writing room, card room, library, and gymnasium are also provided. The dining saloon, the central portion of which has a maximum height of 31 ft., is two decks lower, the principal entrance being situated centrally. Passenger elevators are provided on each side of the entrance, and, in addition, there are two main staircases—one on each side of the ship. A large swimming bath placed forward of the dining saloon forms another attractive feature of the accommodation. In all three classes, about 4,000 passengers can be carried, 850 of the number being first-class; a number of more or less elaborate suites are provided for the latter in addition to the usual cabins and staterooms. The vessel is propelled by turbines of the Parsons' type direct coupled to four propellers and developing a total of 66,000 s.h.p. when running at 180 r.p.m. The high pressure turbine drives the port inboard shaft, and exhausts into the intermediate pressure turbine driving the starboard inboard shaft. The exhaust from the intermediate pressure turbine is divided equally between the two low-pressure turbines, which drive the two wing shafts; one astern turbine is provided on each of the four shafts. Steam is supplied by 48 water-tube boilers of the Yarrow-Normand type burning oil fuel on the White system and working at about 250 lb. per square inch; the total heating surface of all the boilers is about 220,000 sq. ft. It is expected that a speed of 25 knots will be reached when the machinery is running normally. The Majestic, it will be remembered, was built by Messrs. Blohm and Voss, of Hamburg for the Hamburg-Amerika Line, and was originally named the Bismarck, but before her completion she was handed over to the Reparations Commission and was acquired from them by her present owners. We could wish, of course, that the world's largest vessel had been of British construction, but the fact that she now flies the British flag is a source of considerable satisfaction.

Executive Engineer to the Queensland Government.—Mr. James Tearoe, M.Inst.C.E., M.I.Mech.E., has resigned his position as Executive Engineer to the Queensland Government, having completed upwards of 40 years' service.

"STATICALLY INDETERMINATE AND NON-ARTICULATED STRUCTURES."

TO THE EDITOR OF ENGINEERING.

SIR,—I have followed with much interest Professor Lea's article on "Statically Indeterminate and Non-Articulated Structures" which appeared in your journal. The monolithic property of reinforced concrete structures is now generally recognised; such structures are statically indeterminate; the subject of Professor Lea's article is therefore of particular interest to the engineer who has made a study of reinforced concrete.

The two best-known methods of approaching the subject are (1) by the application of Castigliano's theorems and the principle of least work, as ably explained in Professor Lea's article, (2) by what is known as the slope-deflection method. During the last few years much of my time has been devoted to developing another method believed to be new, and to those readers who are not yet acquainted with the principles involved a brief explanation may be of interest. The whole of this treatment is based on an application of Clapeyron's theorem of three moments which has been used by engineers for very many years to determine bending moments on continuous beams. My investigations, which commenced about two years ago, showed me that this old and familiar theorem of three moments lends itself remarkably well to the solution of statically indeterminate problems connected with monolithic reinforced concrete structures.

Certain interesting results were obtained during my investigations. Perhaps one of the most interesting is the location of points of contraflexure in the pillars of a monolithic reinforced concrete structure. If the base of a pillar is fixed the location of the point of contraflexure between ground level and first floor level is a simple matter, as it always lies at a point one-third the height of the pillar measured from the base. The points of contraflexure in a pillar above first floor level are not so easy to locate, and probably for this reason one finds that approximate positions midway between the floors are sometimes assumed. This assumption is justified when considering storeys at and near half the height of a building of many storeys, but in the upper and lower storeys the assumption leads to inaccuracies far greater than might be supposed at first sight. Another matter of interest was the selection of ratios to compare the properties of inertia moment and of length of members of a structure. By selecting pure ratios and by using the theorem of three moments I found that the expressions for bending moments could be reduced to simple forms, and that it was possible to construct a series of convenient alignment charts which greatly simplify the process of designing a monolithic reinforced concrete structure.

Yours truly,
R. J. HARRINGTON HUDSON,
B.Eng., A.M.I.C.E., M.C.I., &c.

LOW-TEMPERATURE CARBONISING.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. A. C. D. Smith's letter on page 462 of your issue of April 14, I am pleased to note, shows that he has gone very fully into the figures given in the article appearing in ENGINEERING of March 24. I am much afraid that it is not possible to deal adequately with Mr. Smith's various questions in ENGINEERING, as far too much space would be required. In a short paper before the South Wales Institute of Engineers, at Cardiff, on the 20th inst., I gave a brief *résumé* of the principal factors governing the economic aspect of our particular retorting process, and, as far as that goes, any other low-temperature carbonising processes as well, and I take the liberty of referring Mr. Smith to that paper.

Dr. Lander, of the Fuel Research Board, in his opening speech on the same occasion, clearly states the Research Board's views as to the values of semi-coke and by-products, and it will be found that the figures I give below are well in agreement with theirs.

It is rather difficult to state exactly what the capital cost of a plant is owing to the uncertain prices of material, it may be 20 per cent. cheaper to-morrow or 20 per cent. dearer, but if a close approximation will satisfy Mr. Smith a 100-ton unit, comprising the following items—producer; retort; driving gear; storage bunkers, with feeding arrangement; dust cyclone; condensers; washers; P. and A. extractors; pumps and boosting fan—will cost about 20,000*l*.—22,000*l*. delivered on foundations in this country.

Under to-day's working conditions, the cost of treating 1 ton of raw coals can, without committing any great errors, be taken as:—

	£	s.	d.
Depreciation on plant	0	1	6
Repairs and maintenance	0	0	6
Cleaning of gas plus water and sundries	0	0	4
Power	0	0	6
Labour	0	1	2
Total cost	0	4	0

It is quite true, that, compared with ordinary producer gas practice, the amount of gas is less, but on the other hand, the net British Thermal Unit value per cubic foot is much higher; and it will be seen that the amount of British Thermal Units recovered is practically the same in both cases, only the yield and quality of tar oils is better in our process. It is, of course, impossible to have "the penny and the bun as well."

We are regularly working our retort with one producer only for the purpose of producing a solid smokeless fuel, and although we do not lay a specific claim to have completely solved the question of low-temperature distillation, we have produced some remarkably good smokeless fuel which, as far as strength, density and homogeneous volatile contents are concerned, is recognised to be amongst the very best ever produced by any process.

Up to the present time there has never been produced enough low-temperature tar oil in this country to enable one to say that the market value is so much per ton or gallon, and as the tar oil has to compete with imported crude oil it will at any rate be safe to say that the value of low-temperature oil is the same as the imported crude, namely, about 4*l*. per ton, or 4*d*. per gallon. Incidentally it has been found that crude low-temperature tar, owing to its high contents of cresols and allied disinfectants, is by far the best wood preserving medium in existence so far.

With reference to the smokeless fuel, the factor which governs the sale price of same is the price at which the raw coal from which the fuel is made is sold, but, although the smokeless fuel is sure to fetch a slightly higher price owing to its higher efficiency and cleanliness, from a business point of view it will be safer to assume that the market price will be the same in both cases.

A market for the surplus gas of 230 B.Th.U. per cubic foot should not present any difficulties as long as the gas can be sold at a price which compares favourably with producer gas.

A balance sheet on the above assumptions will be as follows for smokeless fuel manufacture:—

Expenditure.

	£	s.	d.
1 ton of raw bituminous coal in retort	1	0	0
Approximately 0·25 tons of raw coal fed into the producer and converted into producer gas... ...	0	5	0
Working cost per ton of coal carbonised	0	4	0
Total	1	9	0

Income.

	£	s.	d.
0·75 ton of smokeless fuel at 20*s.* per ton	0	15	0
Approximately 36,000 cub. ft. of gas at 230 B.Th.U. per cubic foot, at 4*d.* per 1,000 cub. ft.	0	12	0
18 gallons of crude tar oils at 4*d.* per gallon	0	6	0
Sulphate	0	1	0
Total	1	14	0
Deduct	1	9	0
Profit per ton of coal	0	5	0

Regarding the capability of the gas, leaving the retort at a fairly low-temperature, of carrying away the tar and oil vapours, we have not experienced any difficulties due to condensation. It is surprising the amount of vapours, or rather mist of high boiling oils, which will remain in the gas even at temperatures as low as 30 deg. to 45 deg. C., in the form of very fine globules, without being deposited by the gas. Take, for instance, a typical tar extracted in the Pelouze from our gas. The temperature of the gas at this particular point is between 25 deg. to 28 deg. C.

The tar fractionated thus:—

	Per Cent. (By Volume.)
Up to 170 deg. C.	4
170 deg. to 230 deg. C.	15
230 deg. to 270 deg. C.	13
270 deg. to 320 deg. C.	41
Residue and loss	27

It will be quite clear that this tar is carried along in the gas in a condensed or rather liquid form in an extremely fine division, or if one could use the expression, colloidal suspension, apart from the amount of lighter oils carried in the form of true vapours and following Henry's law.

Perhaps it will interest Mr. Smith to know that the invention of a suitable stuffing-box arrangement between the fixed and rotating portion of the retort made possible the whole of our retorting system, and is in reality the crux of the whole thing. Our patented stuffing-box arrangement has successfully withstood temperatures up to 800 deg. to 900 deg. C. for weeks on end without showing signs of deteriorating, and this is an infinitely more severe test than actual working practice requires.

Finally, I beg to draw attention to the fact that owing to an error, the name of our company appears as a limited company, in the heading of the article. We are not at present a limited concern.

Yours faithfully,
HARALD NIELSEN.
100, Victoria-street, Westminster, S.W. 1,
April 27, 1922.

"OIL FUEL BURNING."

TO THE EDITOR OF ENGINEERING.

SIR,—Whilst we agree entirely with Mr. Kermode's suggestion in his letters in your issues of March 24 and May 5, that maximum efficiency can be obtained only by attention to the general design of the boiler, and that possibly it may be found that this efficiency can be given only by a type not yet evolved, it may be of interest to mention what can be done with the cylindrical or Scotch marine boiler in the way of economy when associated with forced draught, which he recommends, and also with the preheating of the air.

Tests at our works on a boiler of this type of normal proportions for forced draught showed that when burning 0·686 lbs. of oil per square foot of heating surface per hour, and evaporating 10·92 lbs. of water per square foot of heating surface, an efficiency of 82·3 per cent. was obtained, the temperature of the gases at the foot of the chimney, after leaving the air heater, being reduced to 488 deg. F. The oil used was "Pumpherston," having a net calorific value of 18,770 B.Th.U. per lb. The bars were, of course, taken out of the furnaces, leaving the whole of the surface available for evaporation, and the amount of oil burnt per hour per cubic foot of combustion space (including of course the combustion chambers themselves) was 3·54 lbs. The ratio of total combustion space to heating surface was 0·192, which is nearly double that found in water tube boilers of the three-drum type, so that the Scotch boiler from the point of view of facilities for combustion and absorption of heat, has some advantages, and it would seem that even higher rates of combustion per furnace could be obtained, thus increasing the output, but with a reasonably high efficiency.

Mr. Kermode says that the questions of the bore of the tubes and their spacing merit consideration. The facts stated above suggest that it may be possible in the case of boilers intended to burn oil only that the combustion space capacity in the cylindrical boiler would deal with a higher ratio of heating surface. This might be obtained by decreasing the bore of the tubes and increasing their number. The ratio length/diameter would be increased, and probably also the speed of the gases through the tubes. All these factors would tend to improve the heat transmission and therefore the efficiency, whilst at the same time increasing the output.

We note that Mr. Kermode favours the use of forced draught, but we believe that preheating the air for combustion is even more beneficial for oil fuel than for coal. Just as solid fuel must pass through a complex process of gasification and distillation before combustion can be completed, so the globules of oil must be transformed by heat into inflammable vapour. This process is greatly assisted by the heated air. The chilling effect of the furnace walls, which retards combustion and is accentuated by the absence of a hot bed of fuel, is at the same time much reduced.

Yours faithfully,
For James Howden and Co., Limited,
CRAWFORD W. HUME, *Director*.
195, Scotland-street, Glasgow, May 9, 1922.

"FAILURE BY FATIGUE."

TO THE EDITOR OF ENGINEERING.

SIR,—The undersigned have read with great interest your leading article in the issue of April 28, and would like to make a few relevant remarks which you may consider worthy of publication in your correspondence column.

With the exception of an indirect reference to the work of Mr. Stromeyer, no reference to British investigators is made. Surely the work of Dr. J. H. Smith (Journal of the Iron and Steel Institute, 1910) marked a notable departure from routine methods of determining fatigue limiting ranges of stress. As a result of his work and further developments which have been, and are being, made, such a knowledge of fatigue phenomena has been obtained that the following law may be stated: "If a new specimen be tested in any high-speed machine, the range of stress slowly increased and the resulting strains recorded, the limiting range of stress will be revealed as that at which strains cease to be proportional to the stresses."

A method of obtaining the limiting range under reversed torsional stresses of a material on the Stromeyer machine by a combination of Smith's and Stromeyer's methods was published by one of the writers in *The Engineer* of August 12, 1921. This method has now been applied to (*a*) rotating bar tests, (*b*) reversed bending (plane) tests, (*c*) alternating direct stress tests, and the method established so that a determination of the limiting range of stress can be made by a test on one specimen in the space of a few minutes.

The other of the writers, in the course of fatigue experiments on commercially pure nickel, found similar behaviour to that mentioned as occurring in the 0·02 per cent. carbon material of Moore and Kommers, namely, that the endurance limit was over 50 per cent. in excess of the yield stresses of the material as shown by static tests in tension and compression. The same endurance limit was also found in direct tension and compression fatigue tests in a Haigh alternating stress machine, which appears to dispose of the explanation that Moore and Kommers' result is due to the fibres under maximum stress in a rotating bar test being able to transfer the overload to their less strained neighbours. Further investigations by measurement of strain and temperature rises during the progress of fatigue tests on the material showed fairly successfully that the overload caused large deformations during the first few hundred alternations of stress, but that these rapidly diminished until the material was in a condition in which the elastic limits in both tension and compression were considerably greater than the original yield stresses.

Yours faithfully,
H. GOUGH.
G. A. HANKINS.
National Physical Laboratory, Teddington,
May 3, 1922.

DIESEL ENGINE USERS' ASSOCIATION.—At the next meeting of the Diesel Engine Users' Association, to be held on Friday, June 2, at the Institution of Electrical Engineers a paper on "Marine Diesel Engines," by Mr. H. F. P. Purday, B.Sc., will be read and discussed. Non-members interested in the subject and desirous of attending the meeting can make application for tickets of admission to the Hon. Secretary at 19, Cadogan-gardens, London, S.W. 3.

NOTES ON BLAST FURNACE FILLING.*

By D. E. ROBERTS, M.Inst.C.E., M.I.Mech.E. (Cardiff).

ONE of the most important matters in connection with blast-furnace practice, and one that has probably received more study than any other, is the subject of filling and proper distribution.

The mechanical charging of blast furnaces has developed along two principal lines, the skip and the bucket, and beyond a very brief reference to a few of the best-known examples of each, this paper will be devoted to a general comparison of the two main types.

Fig. 1. ORIGINAL KENNEDY FURNACE

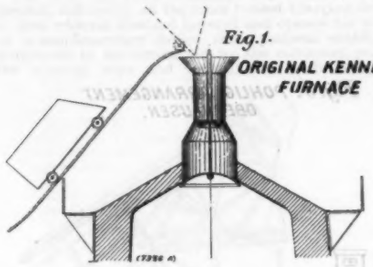


Fig. 1a. Mr F. C. ROBERTS' ARRANGEMENT AT JACKSON O.

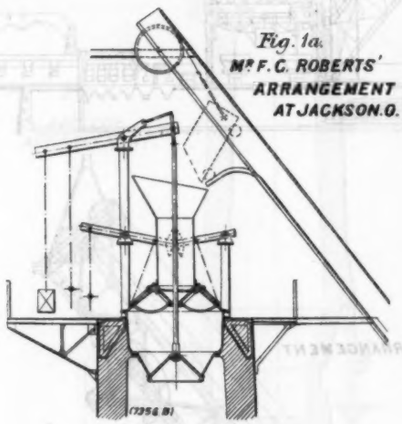
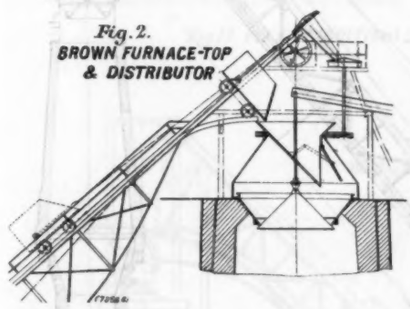


Fig. 2. BROWN FURNACE-TOP & DISTRIBUTOR

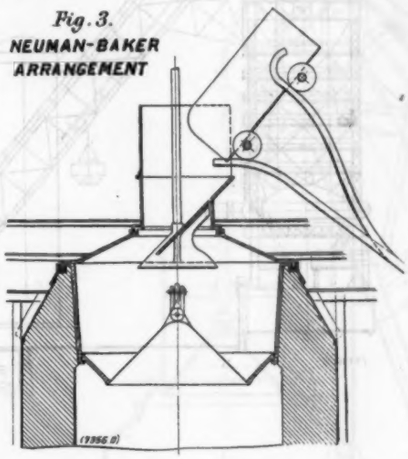


Without going historically into the question of the developments to date, it may reasonably be accepted, as a basis of discussion, that distribution due to properly-controlled hand filling is ideal. The early attempts at replacement were all, with one exception, on skip lines. It was soon found that, owing to the separating or shovel effect of the skip, serious errors in distribution took place. Methods to remedy these errors were the incorporation of various kinds of revolving tops, all of which doubtless in a measure led to improved conditions, and some of which are to-day giving fairly satisfactory results. It must not be overlooked, however, that such devices are but means of rectifying a method of charging that is fundamentally inaccurate, and further, that such additional equipment is not altogether desirable on the top of a furnace, is troublesome to keep in order, and will do much more harm than good should it get out of commission unnoticed for a little time.

The first attempt on bucket lines, by Neeland of Duquesne, was not immediately successful, and was not at the time copied by others. When, however, its characteristics became more fully realised, success followed, and the continued satisfactory operation of the Duquesne plant is a matter of common knowledge in the States, where this system is now being increasingly used. In Europe, it may be said that the Neeland system, with slight modifications, has now become very largely adopted. In England, France, Belgium and Germany about four bucket systems have since 1900 been installed to each skip arrangement, and since 1910 the above proportion has been very much further increased.

The bucket is mechanically quite as serviceable a carrier as the skip, and affords the great advantage of a simple, free and open furnace top, no mechanism being needed to re-arrange the charge and prevent bad distribution. The whole disposition is done properly at the floor level.

Fig. 3. NEUMAN-BAKER ARRANGEMENT



The objections to the bucket arrangement that have been advanced are :—

1. The first cost. The adoption of the ordinary skip incline to bucket-carrying does undoubtedly mean increased weight of structural material, especially if complete stiffness is to be insured. It is a matter for consideration whether the incline is really the best device for handling the large type of bucket that seems to be coming to the front to-day. Various types of chargers of what may be called the vertical-horizontal pattern have been satisfactorily applied. They are easily controlled, simple in construction, and have special advantages when the application of mechanical charging to existing furnaces is considered.

2. The unit charge is said to be too large. It is undoubtedly true that when the bulk of the burden is very fine, as with some American conditions, split charges, that is, thin layers, are sometimes necessary. Strictly speaking, with the bucket the charge can be made anything. For purely mechanical reasons the large unit has the advantage, entailing less wear and tear, slower motion, &c. Should small charges be required, either permanently or for a short period, it is considered better to arrange them in double layers in a large bucket rather than to reduce the bucket to a small capacity to suit.

3. It has been asked—How can a furnace that drives faster on one side than another be filled properly with a bucket? No serious difficulty has been experienced from this cause that cannot in practice be overcome by adjustment at the tuyeres.

Broadly, the above considerations briefly involve the main primary differences between the two systems. More detailed explanations and diagrams follow :—

Fig. 4. McKEE FURNACE-TOP & DISTRIBUTOR

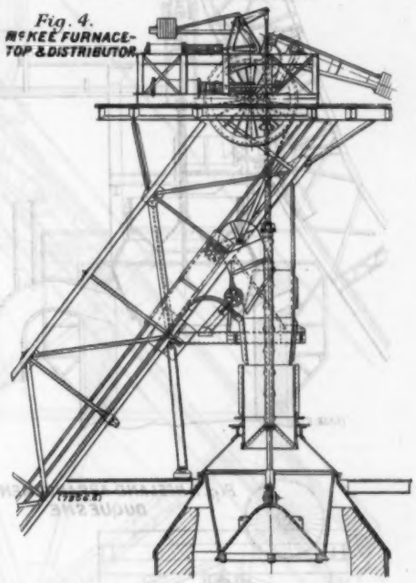


Fig. 5. McKEE TOP WITH BRASSERT GENERAL ARRANGEMENT.

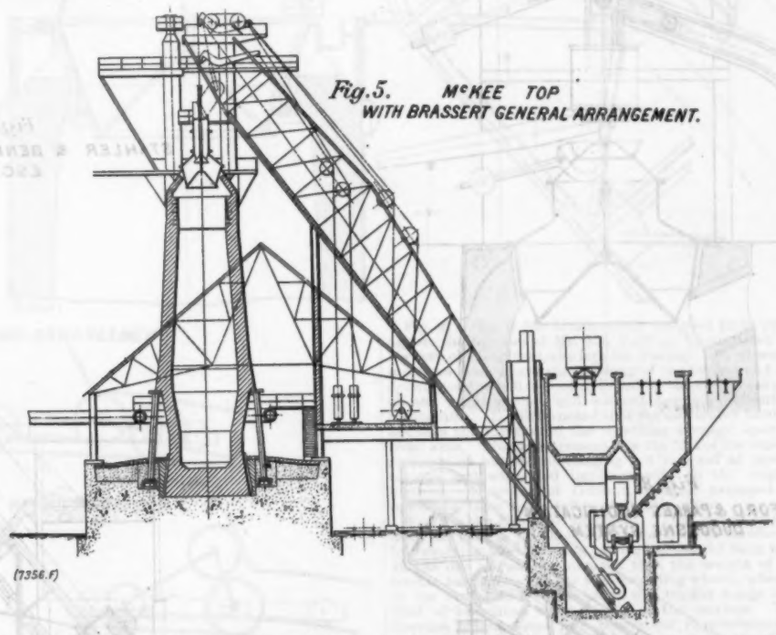


Fig. 1 shows an early application, and is a long chamber of small diameter above the bell. The chamber may be of plain internal diameter as shown, or may be fitted with flutings or spirals with the object of improving distribution. It is not a method, however, that satisfactorily overcomes distribution difficulties, and the height of the chamber also means an increase in the breakage of coke.

Fig. 1A is a fairly modern development, by Mr. Frank Roberts, of the arrangement shown in Fig. 1. It is fitted with equipment much improved in detail, and has a special feature in the four-segment "orange-peel" valve, under the hopper, which provides for the central discharge of the materials on to the large bell.

Fig. 2 is the well-known Brownhoist arrangement, which has doubtless operated in a fairly satisfactory manner at several furnace plants. The principle, as is well shown, consists of a hopper with a side shoot discharge with gas lid. This hopper is automatically revolved a certain number of degrees at each journey

* Paper read before the Iron and Steel Institute, May 4, 1922.

of the skip. The objection to the arrangement is, that a good deal of mechanical rotating equipment is involved on the furnace top, and should it get out of order unnoticed, serious results would follow, as the furnace would be filling on one side. Even when the apparatus is in order, there must be some irregularity : it is obvious that there is a considerable difference between the discharge on to the bell when the hopper shoot is in the line with the skip, in other words, is an extension of it, as compared with the discharge when the hopper is reversed.

Fig. 3 is the Baker-Neuman arrangement, is somewhat similar in principal to Fig. 2, and has been largely applied. The new furnaces at Gary, for instance, were built with this top. Here again the upper bell, with the inclined addition, revolves a certain distance with each motion of the skip. It is a lighter piece of apparatus to move than the "Brown" top, but is subject to the same defect in the event of breakdown, although possibly not to so marked an extent.

Fig. 4 is the McKee arrangement. In principle it is the same in some respects as the others, that is, a revolving hopper, but it has no side discharge or inclined bell. The hopper is just an ordinary plain bell bottom chamber and revolves, like the others, so many degrees with each movement of the skip. In the author's opinion it is a great improvement on the others, and for skip-filling it is being more commonly applied.

Fig. 5 is another illustration of the same device.

Fig. 6 illustrates the arrangement described by Mr. Fred. Clements before this Institute a year or so ago. It is, in many respects, similar in principle to Fig. 4, but employs a slightly different shaped revolving chamber or hopper. This, in the author's opinion, compared with the last-named, has one advantage, and unfortunately a disadvantage. The advantage is that with this arrangement, partly due to the method of depositing the charge, a furnace can be followed up on one side, which is not so easily done by the other. The

Fig. 6.
FURNACE TOP PARK GATE ARRANGEMENT.

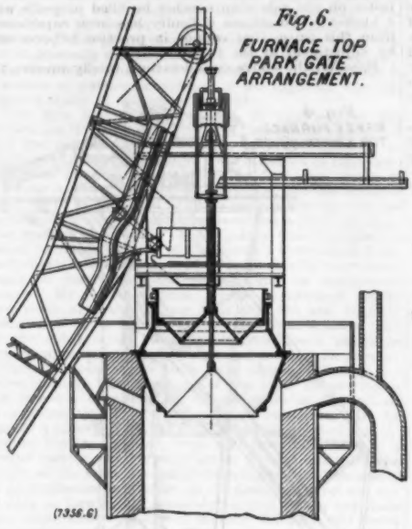


Fig. 9. POHLIG ARRANGEMENT OBERHAUSEN.

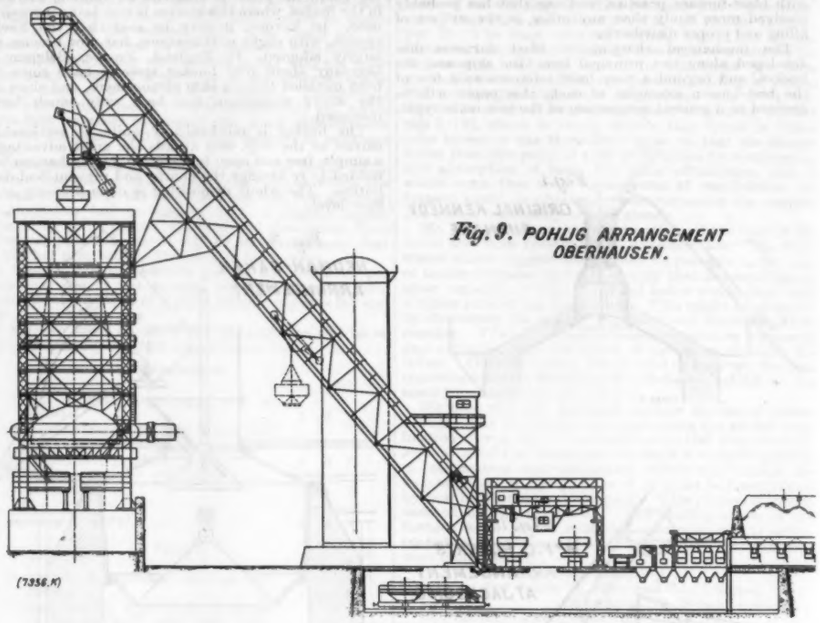


Fig. 7. NEELAND ARRANGEMENT DUQUESNE.

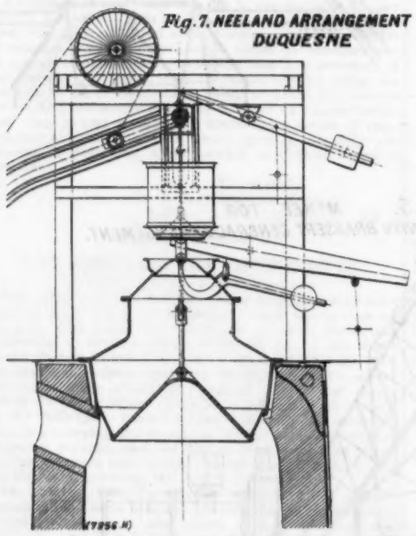


Fig. 10.
STAHLER & BENRATH ARRANGEMENT ESCH

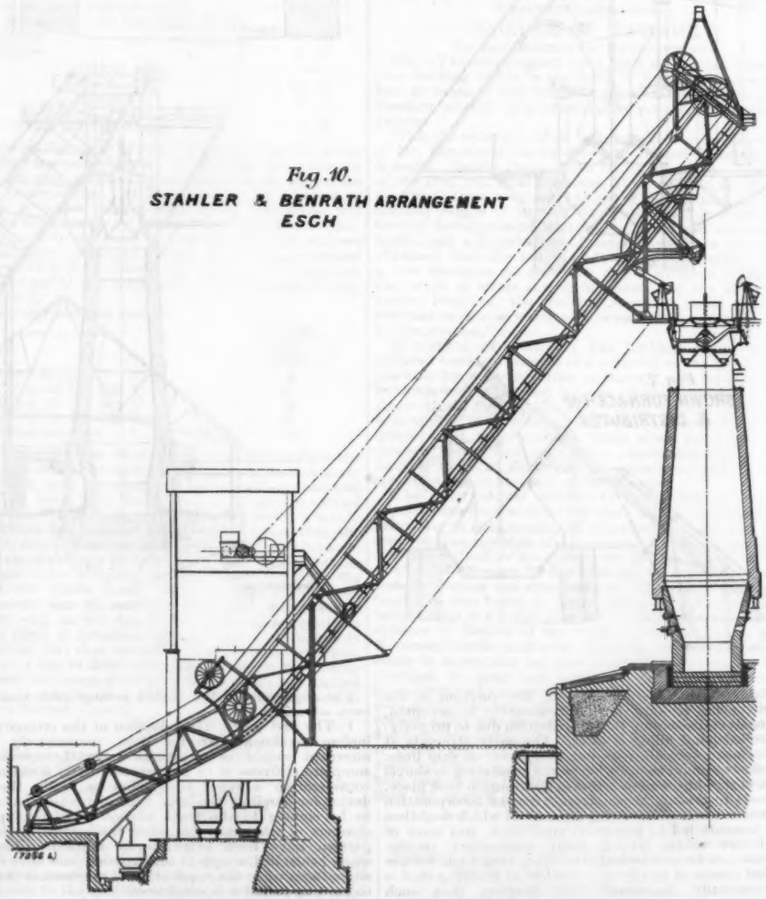
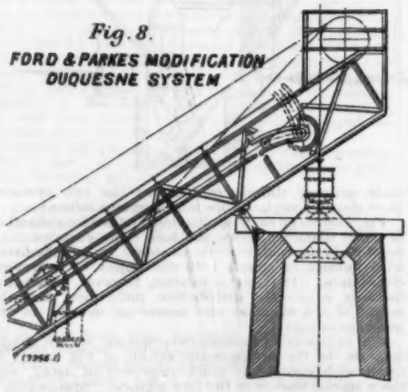


Fig. 8.
FORD & PARKES MODIFICATION DUQUESNE SYSTEM



disadvantage, however, is the introduction of a large hopper, more of the size of that used in the "Brown" arrangement, although, of course, the discharge is central.

Bucket charging is susceptible of various modifications which will now be discussed.

Fig. 7 is the well-known Neeland arrangement as installed at Duquesne, and is just a plain bucket with a bell bottom. The method Neeland employed for lowering the bucket into position is indicated on the diagram. It will be observed that this vertical movement was made by a hydraulic cylinder at the top of the furnace.

The only important difference between this original method and nearly all the other bucket charging devices is, that whereas Neeland lowered and opened his bucket by a supplementary device, other patterns enable this movement to be carried out by the continued pull on the winding rope and without the addition of any supplementary apparatus. On the face of it, that appears an obvious advantage.

The old Duquesne arrangement is, however, a very rigid method, and possesses one special claim often overlooked, namely, that it is possible positively to push the bell of the bucket open, which is very useful if charging, for instance, awkward-shaped pig-bed scrap. With the other methods, with the exception perhaps of Fig. 12, this is not possible, as the charging bucket is suspended by a flexible connection. The first important departure from the Neeland arrangement is that shown in Fig. 8.

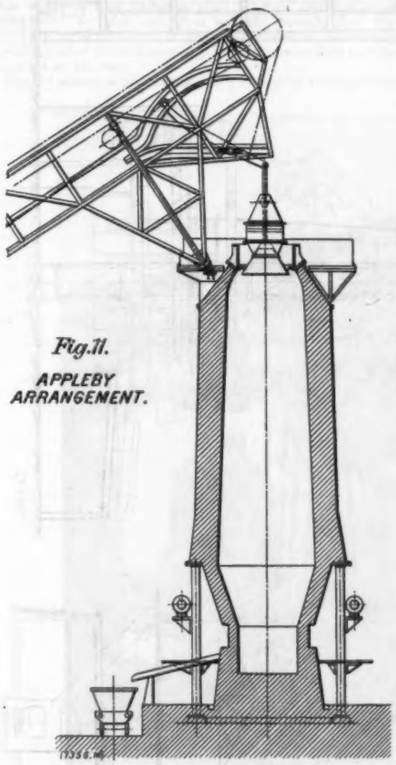


Fig.11.
APPLEBY ARRANGEMENT.

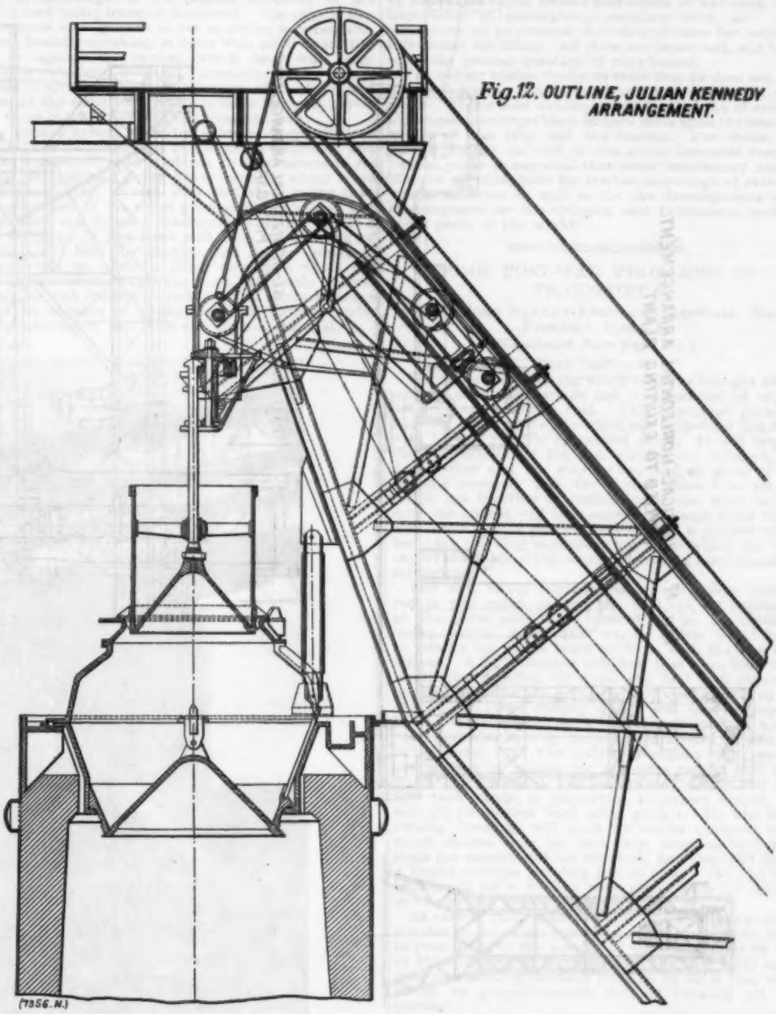


Fig.12. OUTLINE, JULIAN KENNEDY ARRANGEMENT.

Fig.13. RECENT (BRITISH) CHARGING ARRANGEMENT.

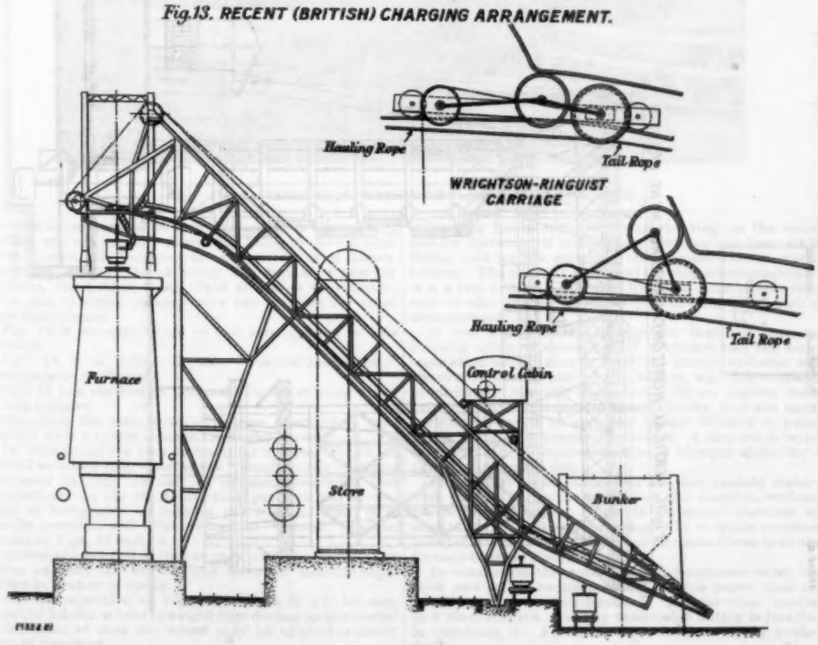


Fig. 8. This is the arrangement designed some years ago at the furnace of Mr. Ed. Ford at Youngstown by his very able engineer, the late Mr. Parkes. The drawing indicates clearly how the lowering of the bucket and the opening of the bell is accomplished by the continued pull on the winding rope, and without any supplementary mechanism. It will be noted that the movement brought about is the rotation of the travelling carriage upon its front axle. This arrangement was the first of the various methods of bucket discharging put forward as modifications and suggested improvements on the original method. A couple of German designs, prepared on much the same lines, followed shortly after.

Fig. 9 is the Pohlig arrangement. This, as will be seen from the sketch, provides for the lowering to be effected by revolving the travelling carriage about the back axle. It has one advantage, namely, that the weight of the bucket hangs between the two travelling wheels, whereas in the Ford and Parkes design the bucket hangs on a kind of horsehead on the front of the carriage. This German arrangement is a theoretical improvement as giving better distribution of weight upon the travelling wheels, but, as will be seen from the figure, the rotating device is a very clumsy piece of mechanism as compared with the simple Ford and Parkes system.

Fig. 10 is the Stahler and Benrath charger, on similar lines to the Pohlig, and in many respects is much the same as Fig. 8, except that the tilting at the top is done by manœuvring the tail of the travelling carriage alone, instead of using a radial sleeve with it.

Fig. 11 is practically a copy of Fig. 10, except that the horse-head of the carriage has been removed. Fig. 12 shows a very ingenious arrangement provided by Mr. Julian Kennedy at the Youngstown Sheet and Tube Company's furnaces, and elsewhere.

One of the difficulties with most bucket arrangements is that, when operated at considerable speed, there is a tendency for the bucket to swing during acceleration and stopping periods.

The arrangement shown in Fig. 12 is exceedingly simple and is perfectly rigid, in other words, no swinging is possible. The carriage is of "Snake" pattern, and it has a kind of parallel motion arrangement beneath it which enables the bucket to be kept always perfectly perpendicular.

Fig. 13 is another modification of a bucket-handling

BLAST FURNACE FILLING.

VERTICAL-HORIZONTAL ARRANGEMENT.
Fig. 15.

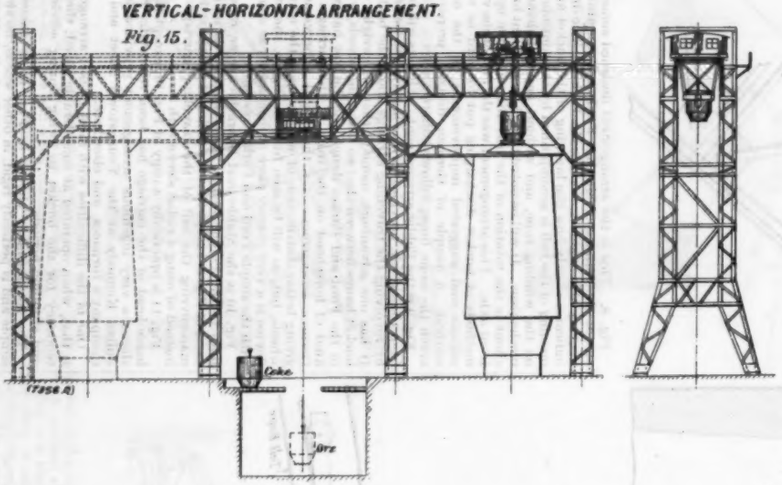


Fig. 17. VERTICAL-HORIZONTAL ARRANGEMENT APPLIED TO EXISTING PLANT

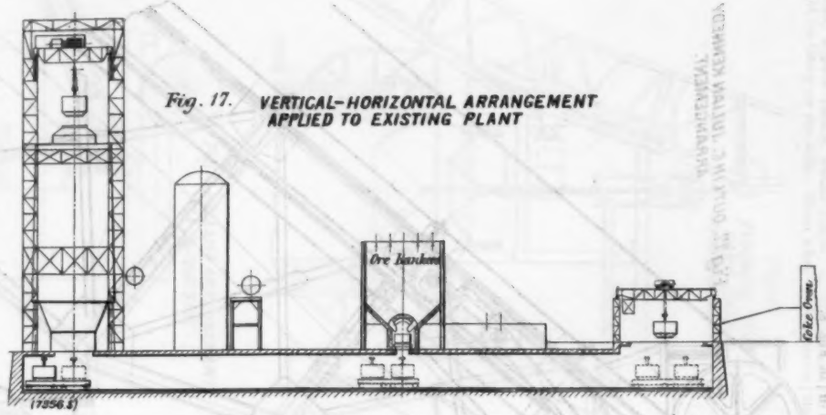


Fig. 16. VERTICAL-HORIZONTAL ARRANGEMENT. CREUSOT

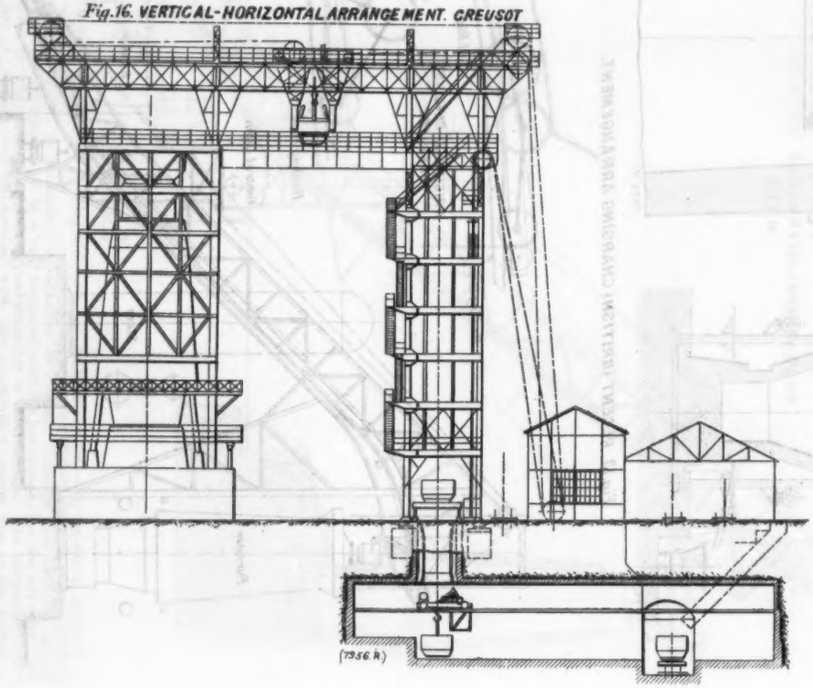
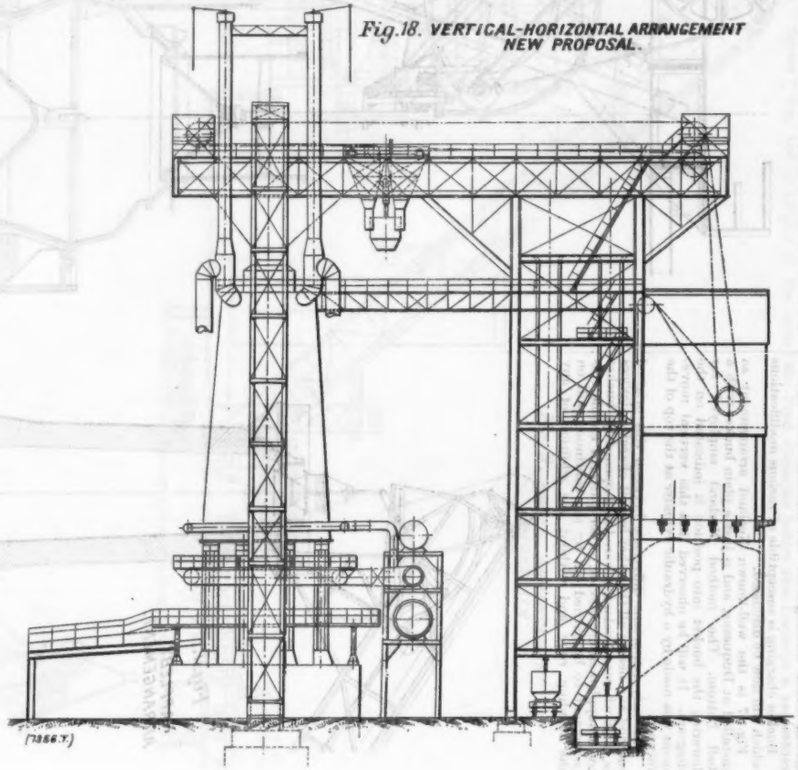


Fig. 18. VERTICAL-HORIZONTAL ARRANGEMENT NEW PROPOSAL.



arrangement. The diagram to the right of the figure shows the type of carriage provided by Messrs. Head, Wrightson and Co., in compliance with a recent specification by the author, to overcome the difficulties of lowering and swinging.

Having outlined broadly a comparison between the skip and the bucket generally, and described the relative advantages and disadvantages of both methods, it may be well to consider whether, if the adoption of the bucket become more or less universal, something in the nature of a system that may be called the "vertical-horizontal" may not be worth consideration.

The best means of carrying the bucket to the top of a furnace is a matter well worth discussion. The incline is eminently suitable to the skip. When, however, the heavier loads to be treated by the bucket are considered, as well as the extra length of stem, the difficulties of swinging and general stiffness of structure required—the rectangular method is, as stated, worth consideration. This method has likewise the distinct advantage of being able to pick up from several points, and the structure is, in addition, of great assistance in facilitating the removal of the bell and any heavy repairs that may be required at the top.

Fig. 14 shows a photograph of a charging arrangement

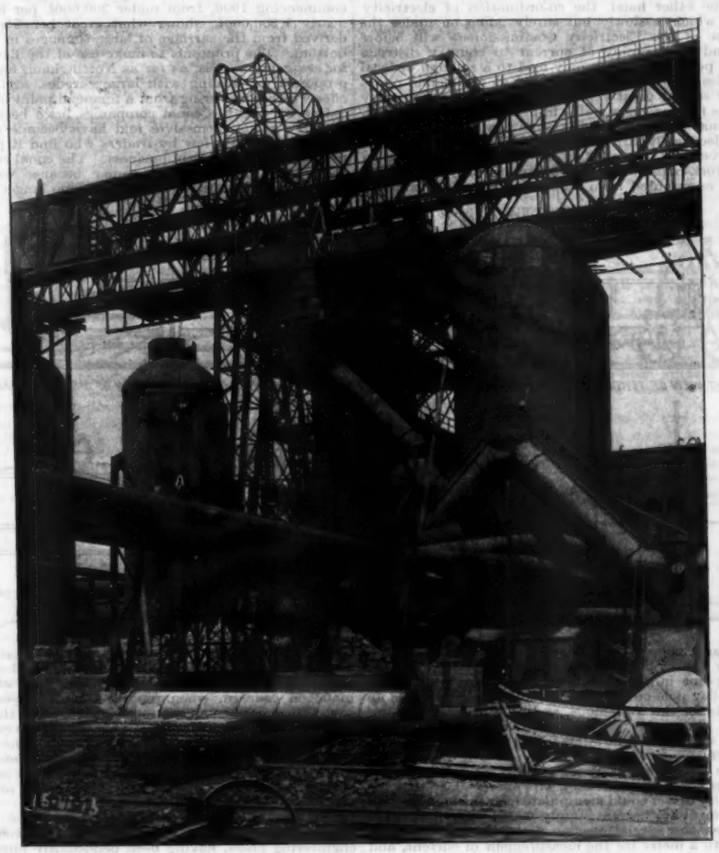


FIG. 14. CHARGING ARRANGEMENT AT ATHUS, BELGIUM.

of which several examples may be seen in the Luxemburg district, the one actually illustrated being in the extreme south corner of Belgium at Athus. It is a heavy structural gantry placed along the top of a row of furnaces, the bucket being lifted at one or two points, while one charging arrangement can provide for more than one furnace.

Fig. 15 is an application of this arrangement in this country.

Fig. 16 is a design of the "vertical-horizontal" arrangement at Creusot.

Fig. 17 is a method as proposed for an existing plant in this country.

Fig. 18 is the same type of charger arranged in connection with a recent scheme for works abroad.

In comparing the two rectangular systems shown, it should be noted that whereas the "longitudinal" designs indicated in Figs. 14 and 15 demand somewhat less expenditure on the structure, they yet lack the advantage of being able to balance the winding load, as is readily possible with the "cross" or "lateral" designs shown in Figs. 16 and 18.

Automatic control is just as easy with the rectangular types as with the incline, and have no disadvantages either in matter of speed.

By an inspection of Figs. 16 and 18 it will be seen that the bucket is held in a rigid cage during its horizontal movement, so that any speed may be applied without fear of swinging.

In balancing up the relative disadvantages of the two systems it must not be overlooked that the skip, especially in its most modern double form, is likely to lose some of its disadvantages if the present tendency of ore dressing and sizing becomes universal. The skip is also the cheapest arrangement as far as outlay is concerned, because, broadly speaking, it deals with small quantities often as against the bucket, which deals with large quantities at less frequent intervals. The former requires a somewhat lighter structure than the other, but as, at the same time, there is more frequent movement there is consequently more wear and tear.

The bucket system provides a furnace top which is practically as simple as that of a hand-filled furnace, and also, as mentioned above, affords an easy means of removing the bell and doing heavy repairs, which is an important matter. Every iron and steel works man knows that one of the worst possible places to put any complicated and delicate machinery is on the top of a blast furnace. It has been said that the dressing of materials will help distribution, but in my opinion it is insufficient to select a filling apparatus which will only do the work under the most favourable circumstances, as with dressed materials. The method chosen should be capable of giving ideal distribution under any circumstances, and with any class of material.

Nothing has a more important bearing on the satisfactory operation of the furnace, the wear and tear of the lining, and its life generally than proper charge distribution. The shovelling effect of the skip is not imaginary; it is a real defect. That was for some considerable time one of the causes of trouble, even with the bucket arrangement.

It was found upon investigation that the material running down a shoot out of a bunker had the same separating effect, that is, that the lumpy material was thrown to the far side of the bucket, and fine material immediately beneath the shoot. Drum outlets have been applied to overcome this difficulty, but the usual method to-day is to spin the bucket while it is being filled. This is a simple illustration of the much more marked positive separation that is brought about by a skip at the furnace top.

The bucket arrangement has another distinct feature with regard to coke, which can be handled without bunkering if desired. This is in many districts an advantage as reducing breakage. It is quite common now for the coke to be loaded at the coke ovens into the furnace buckets direct.

In conclusion the author would emphasise what has been said at the commencement of this paper, that the question of good distribution is a most vital matter in a blast furnace, and any reasonable outlay is justified in obtaining it. For that reason he favours the bucket design.

No reference has been made to other important matters relating to the same subject, such as size of furnace bell in relation to the throat, the correct lowering of the bell without lateral movement or swinging, the importance of maintaining stockline level, and considerations as to internal deflecting devices for radially influencing the filling. All these are important, and bear upon the general question of distribution.

The author wishes finally to state that he does not lay claim to having put forward any new matter in this paper. It has been written purely for the sake of raising a discussion amongst blast furnace users upon the relative merits of the skip and the bucket. The desire for greater output, as well as the much increased cost of labour, make it essential that some satisfactory means may be adopted, both for the reconstruction of existing plants at home as well as for the developments now contemplated in the Colonies and Dominions, and in other parts of the world.

SOME POST-WAR PROBLEMS OF TRANSPORT.*

By SIR JOHN AUDLEY FREDERICK ASPINALL, Past-President, Inst. C.E.

(*Concluded from page 574.*)

COAL SHIPMENT.

QUITE the largest saving which could be brought about quickly is in the carriage and manipulation of export bunker and coastwise coal. This important point is, however, by no means one which can be decided and dealt with by the railway companies alone. It will require the co-operation of the coal owner, the railways, the dock owner and the ship owner, and so great is the possible economy that the sooner these four sets of people get together in conference to see what can be done the sooner will they save those large sums which will result from a proper treatment of a subject which has been too long neglected, but as to which the vital export coal trade of this country demands, a commonsense settlement.

The first thing required, as I have before pointed out in this room, is that the coal tipping appliances at the ports should be altered so as to handle a larger wagon, when the wagon owner could begin to rebuild his wagon stock to fit in with the new conditions. A little thought will show that when both these conditions are filled, all those who deal with export or bunker coal from the pit to the ship, will benefit by the change:—(1) The colliery owner will save money by having fewer wagons at a less capital cost per ton of coal, and also save in shunting work, and require less siding room. (2) The railway company will save in capital cost of wagons for the same reason, will have much less shunting, will save siding room, will haul less dead weight in proportion to paying weight, and will get its wagons back more quickly. (3) The dock-owning company will have its berths occupied for a much shorter time for each ship, meaning that more ships per annum will use the dock, and they will obtain a bigger revenue per foot run of quay. (4) The ship-owner will get a quicker turn round with his ship, so as to give him more voyages in a year.

In each of these cases it means that there are a certain number of pence per ton to be saved, varying no doubt in proportion to the amount of work performed by each of those concerned in the transaction, but in the aggregate representing probably from 1*s.* to 2*s.* a ton, which would be proportionately divided between all four parties.

Our export coal trade has been so disturbed during and since the war, that no figures of tonnage carried are of much use, and one is driven to take the results of 1913 as the last normal year which will indicate the real volume of the business in normal times. If we add to the export coal that used for bunkers and that carried coastwise, we get for 1913 a tonnage of 121,199,000. Some of this was, however, carried by canals to the ports, and this must be deducted if we want to arrive at the rail-borne traffic. Unfortunately no figures for 1913 exist for all the canals which give this figure, but 1921 figures show that 5,528,676 tons were so carried. If, as a rough indication, we use this figure and deduct it from the total of 121,199,000 tons, we get an estimated figure of 115,670,324 as the shipment coal tonnage carried by the railways for export, for bunkers and for the coast-wise trade, and if you multiply this by 1*s.*, you reach the very large figure of 5,783,516*l.* a year for each shilling gained, as a possible ultimate saving to be divided amongst all the parties by getting rid of our very old-fashioned methods. These total figures would only be reached when the complete change of rolling stock had been made, but the immediate change of the lifting appliances at all those places round the coast, where they are of antiquated design, could be effected quite rapidly, so that enlarged wagons could be safely sent to any port, and this would at once begin to tell. It is probable that the 288 appliances which must be altered would entail an expenditure of 3,000,000*l.*, the interest and additional depreciation on which is a very small matter compared with the aggregate reduction in expenditure on haulage and handling to the sea coast. The great coal-carrying railway companies have thus, in my view, more to gain than those who are less concerned with mineral traffic, and they and their traders have a great opportunity of saving useless expenditure.

The railways themselves use about 13,000,000 tons of coal per annum, and only a very small proportion of this is carried in large wagons. Further, when the coal has to be handled in loading it on the locomotive tenders, it is mainly dealt with by hand. Here are two cases where large daily economies can be effected, first,

* The "James Forrest" Lecture, 1922, delivered before the Institution of Civil Engineers, May 2, 1922.

by carrying coal in larger units, and, second, by the use of mechanical coaling appliances. It does not appear to be likely that the railway companies can effect any very large economies in the consumption of coal for their own purposes. Speaking generally, the coal consumption on railways has been watched with the utmost care for many years, though no doubt in the old days when each driver had his own locomotive, there was a rivalry for good results which kept down consumption, and now the locomotive which has many crews burns somewhat more. The consumption per horse-power with electric locomotives will, however, show a saving. In connection with industrial operations at large works in northern industrial districts a somewhat remarkable set of figures, showing the economy obtained by electrical operation of machinery where little care had previously been taken about coal consumption, is found in the report of the Coal Conservation Committee (Cd. 9,084, page 26), where they show that in a certain area the average coal consumption per horse-power-hour worked out at 7 lb., and that, after connecting up those numerous works, which, in the aggregate, absorbed 343,000 h.p., with a power company's mains delivering 560,000,000 horse-power-hours at the consumers terminals, the consumption fell to 1·54 lb., representing an enormous saving of 1,365,000 tons of coal per annum. I mention this fact, as it seems that industries generally are likely to benefit more from coal-saving than railways.

CONTINUOUS BRAKES FOR GOODS TRAINS.

We recently had two papers before the Institution on the applications of continuous brakes to railway wagons, and it was very opportune that these should be brought forward, as the time has certainly arrived when the much more rapid equipment of wagon stock with brakes must be considered if we are to speed up our goods services and have the power of clearing our main lines with greater rapidity. It will mean, no doubt, a considerable expenditure of money, but there would be little difficulty in showing that this would be remunerative. Time spent by labour has nowadays become so costly that a new view-point must be taken in regard to railway appliances.

I think it is interesting to look back to some of the earliest attempts at continuous brakes, which were made long before the use of the fluid-pressure brakes of to-day. As far back as 1853 Mr. Newall, of the East Lancashire Railway, had an effective form of continuous brake, which was applied by hand by both the fireman and the guard by means of a continuous shaft carried over the roofs of the carriages, but coupled between the carriages by two universal joints and telescopic sliding arrangement to allow of the play between any two carriages due to the elasticity of the draw and buffer springs. In those days the amount of slack to be taken up was considerable, and I find a note of my own that even in 1870, on the London and North-Western Railway, the extreme play of 16 vehicles running from Stafford to Crewe was found to be 103 in., or 6½ in. per vehicle, which was, no doubt, about the same as that on the East Lancashire Railway, necessitating the telescopic arrangement I have mentioned. Upon the application of brakes this play would become much more. I have had a print of this form of brake reproduced in Fig. 5, annexed.

Later on the arrangement of shafts above the carriages was replaced by a similar but better arrangement running under the carriage frames, and embodied the best points of what was known as Fay's brake, which was adopted by the Lancashire and Yorkshire Railway in 1857. A combined arrangement, known as the Fay and Newall brake, was subsequently adopted. As there was great rivalry between Fay and Newall in 1858 Colonel Yolland, for the Board of Trade, carried out certain competitive experiments on the Accrington Incline to test their merits, but I think it is of more interest to us here to recall that that veteran engineer, Dr. Unwin, then working with Sir William Fairbairn, was concerned in the detailed competitive experiments with the same brakes on the Lancashire and Yorkshire Railway in 1859. How times have changed when we find in William Fairbairn's paper, read before this Institution in 1860, that the whole train only weighed 26 tons 10 cwt., though it consisted of three carriages. The kind of carriage is shown in the illustration of the Newall brake. To-day we may, in the case of a passenger train, require brake control to moderate the speed of a train weighing 500 tons, and this is effectively done in a much more rapid way by fluid pressure brakes, and I hope before long to find that our heaviest goods trains, which at present are about 1,200 tons behind the engine, are effectively braked.

This naturally brings one to consider the question of wagon couplings, as in some recently-described experiments screw couplings were used, whereas the ordinary three-link coupling allows so much slack that no really rapid application of a continuous brake is possible without serious risk of broken couplings and other damage. As the three-link coupling is already recognised as being one of the things which stand in the way of heavier loading of trains in this country, it will not be surprising to find that some attempt is made to introduce a central buffing coupler with the minimum of possible slack. This is one of those things which have been so long discussed, but so often postponed, becoming the more necessary when you have efficient brakes. This would in time involve the abolition of the side buffers, which no one would regret. These rolling stock changes, however, must perforce take many years to accomplish, for financial reasons, as it is not likely that they could be dealt with in a wholesale way, but would have to coincide with the rebuilding of wagon stock, which in ordinary times proceeds for all purposes at about 1,000 wagons a week, if a 25 years' life is accepted as the average, and it will be recognised that until all wagon stock was fitted, none of the existing couplings or buffers could be removed. Agreement amongst the owners for this continuous policy of alteration would have to be reached, with a very full knowledge of all the technical difficulties.

SUPPLY OF ELECTRIC CURRENT.

There were at one time great hopes that the supply of electric power for traction and other purposes would be much cheapened if available water power was made use of, but recently the Water Power Resources Committee have told us how much power we may expect to obtain in Great Britain if the most prominent sources of supply are made use of; but while they are able to point out that they might develop 250,000 kilowatts (continuous) per annum, it is quite evident that the geographical position of these supplies will really only benefit certain localities, and that for traction purposes we must still rely largely on coal. It is remarkable that England only contributes power for 20,440 kilowatts, Wales 35,900 kilowatts, and Scotland 194,965 kilowatts. We cannot, therefore, look forward to any great reduction in cost of current for traction purposes from this source, when speaking of the whole position, and noting the uneven distribution of water power.

On the other hand, the co-ordination of electricity supply which is slowly but surely going on under the guidance of the Electricity Commissioners will before long lead to a supply of current to country districts being a possibility which may lead to a re-birth of local industries. If current can be sold at reasonable prices we may see the great extension of the use of the trolley omnibus for passenger traffic in preference to the petrol-driven machine, and, in addition, a new use of the motor lorry electrically driven taking its current from the same overhead wires. Let us imagine a number of small workshops lining a country highway, all taking current as required from bare overhead wires attached to the same poles as carry the brackets for the contact wires for the trolley services. The motor lorries could at any point in the road draw up at the curb, swing their trolley pole out of the way, and deposit or take up the goods for the workshops, and then proceed on their journey, giving the frontager a most convenient goods delivery service without interrupting the flow of ordinary road traffic.

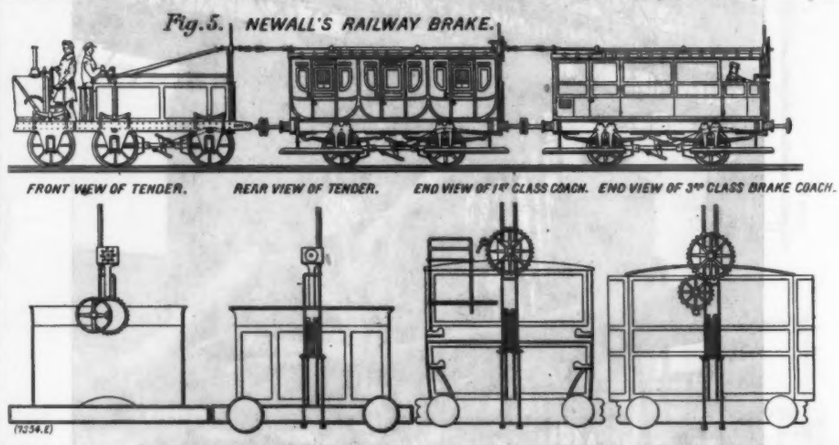
Where it was necessary to go into a workshop yard the owner could have a trolley wire overhead, so that the motor lorry driver could manipulate his vehicle as desired. The payment for current supply would present no difficulties, as the special electric motor lorries would be fitted with a meter for the measurement of current, and each motor lorry owner would pay for current directly to the vendor. It is quite true that the trackless trolley system has not made as rapid progress as was expected, and this is indicated by the fact that in 1919 (the latest year for which figures are given), the total number of car miles was slightly under a million, but it is a system of much promise, and has been remarkably free from accident.

It appears to be much more likely that the extension of the electrical operation along main roads by means of trolley vehicles will be of value to local industries than any possibility of the extension of light railways. Light railways have not been encouraged in this country, and Part V of the Railways Act, 1921, does not help them very much. The Report of the Light Railways (Investigation) Committee* is much more helpful if it is worked to, and may possibly lead to some improvement. They say: "We are convinced that existing notions with regard to the construction and operation of light railways generally are based upon experience originally gained in the construction and working of the great main lines, and that main line traditions have governed and hampered the economic development of the small undertakings."

"Light railways, in our opinion, should be regarded from quite a different angle. We think that instead of endeavouring to maintain standards of speed and service somewhat akin to those adopted by main line undertakings, it should be recognised by all concerned that light railways are in an essentially different category, and must depend for their success upon emancipation from main line conceptions of construction and operation. We are satisfied that a lower standard of speed is a first essential, and that, with the adoption of such a standard, the necessity for elaborate methods of construction and working would largely disappear, with the result that the economic position of the light railway industry could be radically improved, and that without any serious sacrifice of efficiency."

* Report of Light Railways (Investigation) Committee, 1921.

Fig. 5. NEWALL'S RAILWAY BRAKE.



CANALS.

As to the merits of canals, about which there is so much vain hope, there seems to be much misunderstanding, and we repeatedly see strong statements made by writers who urge that their renewed use would lead to great economies in transit. The fact, however, which has to be faced is that the days of the small barge canal are gone, and the sooner we set about discovering a good use for these properties the better. Most of the small barge canals can only take 30-ton boats, and the locks measure but 70 ft. by 7 ft.

The greater canals, like the Manchester Ship Canal, which permit of the passage of large cargo steamers, stand on an entirely different basis. A navigation such as this, which increased its gross takings in 20 years, commencing 1900, from under 300,000*l.* per annum to nearly 1,500,000*l.*, shows what great benefits may be derived from the carriage of large tonnages in the same bottom. The proposals to make use of the River Trent for sea-going vessels, as far as Nottingham, and similar proposals for dealing with large cargoes, are the only ones worth considering from a financial point of view.

One by one the canal companies have been ceasing to carry goods themselves and have become mere toll takers from those few by-traders who find it profitable to carry on some sort of business. The canal companies have been driven to this course because wages and materials are so costly that they can no longer compete with the railways, notwithstanding the fact that railway charges are so much higher than they used to be. Even the owners of the Bridgewater Canal, an efficiently managed concern, when reporting for the year 1921, say, with regard to an increased net revenue, that "the improved result was almost entirely due to the curtailing of the carriage of traffic by the company." The Weaver Navigation no doubt suffers to a certain extent in the same way, but its capacity has been so much improved by engineering skill that much larger boats of 250 to 300 tons burden are in general use.

The Air and Calder Canal, which is so often spoken of as a fine example, is an instance of well thought-out engineering plans, having been persistently pursued for many years. These plans have produced what is probably the cheapest method of conveying coal from the colliery to the ship that can be found anywhere in the world. The 40-ton boats run right under the colliery screens, the coal falling direct into them. Then they are formed into a train of boats of from 25 to 30, which is hauled by a tug to Goole. The boat train thus carries 1,200 tons. Having arrived, each boat goes under a hydraulic tip, which lifts it bodily out of the water, and then tips the coal direct into the ship's hold.

Local circumstances no doubt favour this method of treatment, and the level country admits of it, but still it is a good illustration of methods, which have been in existence for many years, and of the application of engineering principles to cheapening the cost of transport. Its importance is measured by the fact that in 1913 this canal carried 2,563,067 tons of coal.

As one example of what may be done with some of our disused canals, I may refer to a proposition recently discussed as to the abandonment of a portion of the Chesterfield Canal, which joins the Trent below Gainsborough. It has been proposed to abandon that part which is between Chesterfield and the Norwood tunnel, and make use of it for a road 11 miles long. As to the merits of this individual project, I do not give an opinion, but it appears to me that this method of the use of properties now lying idle or but slightly used has many attractions from the point of view of the public, who want their goods carried quickly. Great stretches of the roads laid on the canal beds would be almost absolutely level, and it would only be where there were locks or where low bridges were found that gradients

would be necessary. Once made, these roads would enable motor traffic of all kinds to pass, and rapid communication would be substituted for that slow movement which is inseparable from water-borne traffic on narrow waterways. Should any Parliamentary sanction be given to the conversion of canals into roads for motor and other traffic, one considerable source of income will be lost to those canals which, when passing through industrial centres, make a large revenue out of the sale of condensing water used by the various factories on the canal banks, and the factories will have to seek other sources of supply. If any large reservoirs of water be rendered available because the canals cease to require water, one naturally presumes that attempts will be made to conserve this water for power purposes so far as its limited supply will admit.

It is a curious historical fact that the owners of canals at an early period recognised that there was hardly any possibility of their continuing for any great length of time to carry goods at remunerative rates when they were faced with the competition of railways. The Manchester, Bolton and Bury Canal is an illustration of this, as the directors sought power at one time to alter it into a railway, but ultimately abandoned that idea and made a railway themselves between Manchester and Bolton, both the canal and the railway being absorbed by the Lancashire and Yorkshire Railway in 1846. A more striking instance of this view of canal conversion is shown in evidence which was given when, before the Select Committee on Railways and Canals Amalgamation so far back as April, 1846, Sir F. B. Head, Chairman of the Grand Junction Canal strongly urged that the canals should be converted into railways. Amongst other things he said:—"I submit that it will become the interest of the community to allow the whole network of inland navigation which now covers the country to be converted at its own expense into a general system of cheap rival railroads." He said that "Mr. Cubitt had declared as his decided opinion that the conversion of the Grand Junction Canal into a railway was not only practicable, but that the gradients were peculiarly eligible and superior to the generality of railways."

Sir F. B. Head emphasised his statements by producing certain tabulated statements, which showed that railway competition had had the effect of reducing canal charges for a mileage of 97 miles from 16*s.* 3½*d.* to 2*s.* 0½*d.* for sundry goods, and from 9*s.* 1*d.* to 2*s.* 0½*d.* for coal, a striking instance of the advantage the railways brought to the trade of the country. This foresight of a canal company's chairman has been strongly borne out by the financial condition into which the canals have fallen to-day. The serious water competition which our railways have to face is not that of canals, but the coastal shipping.

It should always be remembered that there is no town in England that is more than about 65 miles from the sea, and if railways are to convey anything between coast town and coast town their rates must be regulated by the sea-borne traffic, and even central cities like Birmingham have great advantages from the competition of both eastern and western ports.

Mails and Aerial Transport.

From the earliest days it has been customary to expect the delivery of messages to be effected with the greatest possible rapidity. This eventually led to the highest speeds being called for in the case of mails, demanding the utmost punctuality of departure and arrival, accompanied by careful measures of security. This in turn led to a demand for the travelling public to be able to travel in the same conveyance, both for the sake of speed and in order that they might participate in the precautions taken for safety. Hence our old mail coaches of 1784, our mail ships and our mail trains which began in 1830, and now our mail-carrying aeroplanes, each in their turn indicate the promptitude with which the improvements of succeeding ages are seized upon to effect rapidity of communication. Our most active newspapers do not consider their circulation perfected unless by means of the aeroplane they can deliver papers to their readers in Paris as soon as they can in London. As to the aeroplanes for carrying mails, we may yet see that for travelling over savage countries they will be adequately armed so that their crews may be able to take care of themselves in cases of attack. Such protective provision for mail services will not be new in the history of the country, as in many cases the mail coaches were armed, and the Post Office which at one time ran mail ships from Falmouth to many ports abroad armed them in a most effective manner, and no doubt instructed their masters that the armament was only to be used in defence; but in those days of 1688 and subsequently, the captains could not resist attacking a French or Spanish ship, and brought many a valuable prize into their port. Thirty-nine packets were at the command of the Post Office, which was then presided over by two men who were known as "My Lords the Postmasters General."

It would appear that the Government of the present day has serious hope that some form of aeroplane can now be produced which will start away from a very small area of ground, or they would hardly have offered such a large money prize for a successful machine. The possibility of producing a machine of the helicopter type with a positive vertical rise may have an important bearing on the construction of future large buildings. His Majesty's General Post Office might become the real starting place and the landing place of the Postmaster's fleet of aeroplanes, rising from or alighting on a large flat roof. It is easy to imagine that the modern hotel lift will convey the guests upwards to a flat roof, and the passenger for Paris or elsewhere will take his place in the aeroplane as easily as he does now in a taxicab on the street level. For the general public could not many of the squares of London which now contribute but little to the use or pleasure of the ordinary inhabitants be formed into the starting-places of the future flying machines, thus avoiding the loss of time and the inconvenience of having to travel to the outskirts of London before being able to get into an aeroplane?

We have recently been told by Sir Henry White-Smith that the cost of carrying a passenger from London to Paris works out at £7 1*s.*, or 7*d.* per passenger mile, and that carrying goods costs 7¼*d.* per lb., or 5*s.* 8¼*d.* per ton per mile. For the more valuable classes of goods this is not a matter of great importance, but the cost per ton-mile must be brought down if any goods of an ordinary character are to be carried.

The possibilities of rapid and commodious transport by air have as yet been barely touched by the successes of the past, and we shall see the advent of great improvements if the engineering talent of to-day is encouraged as it should be. Modern writers who have had the experience of air travel, and watched each successive advance that has been made, have again and again pressed that civil aviation should receive considerable national assistance, and they point out with great weight how dependent we shall be on aviation in the future for the defence of our country. It is a sad fact that we should not even know anything like what we do about it had it not been for the constant experiments during the war and the sacrifice of some of our finest manhood. To depend in future merely upon what our army or our navy can do with aviation in times of peace, would mean the slowest possible progress, through want of varied opportunity of experiment.

The wonderful position which our nation obtained with regard to shipping, came about by the ever-present demands of commerce, calling for the highest speeds, combined with the greatest economy of propulsion. The perpetual vigilance of the navigating officers, combined with the investigating powers of the engineers, led to each possible improvement of the ship, or of the machinery, which they might suggest being seized upon at once by the builder and the owners, as necessary for commercial progress. The progress of the Navy from the structural and the propelling point of view, followed the lessons gained by the mercantile marine, and the builders of our vast commercial fleet were able to give to the fighting ships of the nation the whole benefit of the knowledge which they had gained in the construction and trials of the very much greater fleet of ships of commerce. The same methods of gradual and persistent investigation which have been applied for so many years to the ships of the sea must be hastened and applied to the ships of the air.

For the ships of the air we have hardly any such wide experience to guide our constructors, and it seems only a reasonable precaution that we should give national help to encourage private enterprise to develop and improve this new art, every invention connected with which would be available for our fighting air fleet, and the experience gained would probably cost the nation far less than the limited experiments of Government departments. The wider the circle is spread within which to gain our much needed knowledge, the greater security we shall obtain in the hour of need. We require the dual protection of both kinds of ships, and we may have to vary somewhat Sir Westcott Abell's definition of sea power where he says: "Sea power is the combination of a healthy commerce and mercantile marine with the military navy which ensures by force of arms such protection as will enable the unarmed vessels to carry out their functions." Such a definition will have to be applied in reference both to the sea and the air.

There will probably be common agreement that at no time in the history of this country has national transport been so intimately connected with the necessities of national defence.

THE EFFECT OF OXIDISING GASES AT LOW PRESSURES ON HEATED IRON.*

By Professor H. C. H. Carpenter, F.R.S., and Miss C. F. Elam.

The experiments to be described in this paper originated in the following way. The authors were experimenting with the vacuum etching of copper which was heated in a silica tube, at temperatures in the neighbourhood of 1,000 deg. C. The metal evolved a considerable volume of gas which, if allowed to remain in the tube, caused it to blister. If, however, the gas were pumped off as soon as it was evolved and the vacuum maintained, the copper remained bright and quite free from oxidation. Under these conditions the structure of the copper grains was rendered manifest by what may be termed a heat etch. It so happened that on one occasion Armco iron was placed in the tube with the copper, although not in contact with it. The tube was then evacuated and heated to about 1,000 deg. C. The gas evolved from the two metals was not pumped off, but allowed to accumulate in the tube. At the conclusion of the experiment, when the metals were withdrawn from the tube, it was found that each of them had altered considerably in appearance. On the one hand, the copper was found to have become coated with a layer of blue cuprous oxide, which in some places covered the metal completely, whereas in others it took the form of six-pointed stars deposited on the metal. On the other hand, the iron was distinctly lustrous, if rather dark, and appeared to be very deeply etched. Both specimens had been originally polished and sufficiently etched to show the outline of the crystal grains.

An experiment was then made by heating the iron itself in the absence of copper, and tests were made with Armco iron, electrolytic iron and Swedish iron. In each case a considerable volume of gas was evolved, but no etching effects were produced and the iron appeared to be slightly oxidised. The characteristic etching effect observed in the previous experiment therefore was evidently due to something evolved from the copper.

A series of experiments was then instituted to study the progress and characteristic features of the etch produced on the iron when heated with copper. In all these cases the metals were separated from one another in the tube. The structure of the iron as revealed under the microscope was found to depend both on the period of heating and the temperature. After short periods, such, for instance, as half an hour, at 1,000 deg. C. the surface was found to be covered with small, somewhat irregular facets, whose orientation was constant on any one crystal but differed as a rule on passing from one crystal to another. Fig. 1 shows the structure, at 300 diameters, of the surface of the copper. This is hardly etched at all, although evidences of twin crystals are manifest. In the centre is a blue star of cuprous oxide of very characteristic appearance, and deposits of this constituent are also visible in other parts of the field shown. Fig. 2 shows, at 300 diameters, the appearance of the surface of the iron after the above treatment. Portions of three grains are visible. On each of them will be observed characteristic facets which are constant in direction on any given crystal, but vary from one crystal to another. There are also decided differences of level between the tops of the facets of the adjacent crystals. Steeply sloping surfaces connect one grain with another, and these slope to different extents. Between one crystal and another the etching is so deep as to produce what may be called a valley.

The differences of level on passing from one grain to another became still more marked as the heating was carried further. The individual facets then became larger and more regular, but the surface was rendered more uneven. Fig. 3 shows, at 600 diameters, the structure of Armco iron after the more prolonged etching. Regular brick-like facets are visible in the centre of the field. The dark area bounding these on the right is a sloping boundary, while the facets beyond are out of focus owing to the difference of level. Fig. 4 represents, at 300 diameters, the structure of two adjacent grains of electrolytic iron which are much larger than those of Armco iron, and are both approximately in focus. The facets in the upper half of the field strongly suggest an orientation parallel to the cube face, whereas those in the lower half represent a section of a crystal cut obliquely. Not only were the crystals of electrolytic iron larger than those of the Armco iron, but also the facets themselves.

On heating for a longer period, say for 2 hours, the surface became still more uneven and was found to be covered with perfectly regular squares, rectangles and triangles, together with other figures of less regular shape. Figs. 5 and 6, at 600 diameters, are typical examples of the structures thus obtained. In the former the rectangle etch figures predominate and in the latter the triangle. In these cases, owing to the very deep etch, only certain parts of the field can be obtained in focus at any given time. It was observed that the size and general form of the figures varied somewhat in different experiments owing, doubtless, to slight differences in pressure, and to variations in the composition of the gases evolved from both metals. Occasionally very minute etched figures were obtained, such as are illustrated in Fig. 7, at a magnification of 600 diameters, which represents part of one crystal in which the etched figures appear as minute squares and rectangles. Substantially the whole of this field is in focus. The three or four irregularly-shaped figures observed are due to slight porosities in the iron.

It remains now to consider what the etched figures really represent. The authors' first idea was that the structures observed were those of the etched iron, more particularly as the form of the figures agreed very well with what is known as to the crystal forms of gamma and alpha iron. It very soon became evident, however, that the hypothesis was not correct in this form. It was found that, under certain conditions, small black shining crystals were formed on the surface of the iron, in addition to the etched figures described above. It was thought that these might be an oxide, and in removing some with a penknife in order to test it with a magnet it was noticed that the "etch" layer could also be removed, revealing unaltered iron underneath. It appeared, therefore, that the characteristic etch figures were due to an oxidation of the iron during heating, and that accordingly they must be ascribed to an oxide and not to the metal. General support to this view was given by the fact that the copper itself was, as has been mentioned, also oxidised, the surface in certain places being almost completely covered with the characteristic blue cuprous oxide.

Further experiments were then carried out to determine what relation the structure of the oxide bore to that of the iron. It was noticed that if the specimen were heated to 1,000 deg. C. several times, there was no change in the shape or size of the characteristic etch figures, although it is obvious that on every occasion a change in the crystal form of the iron itself must have taken place on passing through the Ac3 inversion and back again through Ar3. In other words, it is clear that the alpha to gamma and gamma to alpha change had no influence on the facets once they had been produced. Moreover, on marking a particular area before heating it could be shown that its structure corresponded with that of the original alpha iron crystal. The boundaries were the same in both cases. On repolishing and etching after heating it bore, however, no relation to the metal underneath, which had recrystallised in passing through Ac3 and Ar3. Furthermore, upon

* Paper read before the Iron and Steel Institute, Thursday, May 4, 1922.

heating the specimen of the iron below 900 deg. C. it developed the same characteristic etch facets as at 1,000 deg. C., although the time required was considerably longer (a minimum of 2 hours). It is clear therefore that the formation of the oxide begins below 900 deg. C. and that it takes its shape from the structure of alpha iron, and having once begun it continues to grow, regardless of the phase changes which take place in the iron underneath on passing from alpha to gamma and back again. The authors do not regard the process merely as an oxidation of the iron crystals, by means of which the structure of the iron is made manifest, so much as a growth of crystals of an oxide, the orientation of which is determined by the iron on which they are first formed. In certain instances the valleys produced at the boundaries are caused by the growth of oxide crystals away from the true boundary in two directions, the slopes of the valley being made up of the "sides" of the crystals. It will be noticed that these are striated in a regular manner corresponding with the orientation of the facets observed on the surface.

The fact that one substance will assume the same orientation as that of another on which it is crystallising, provided they are isomorphous, is well known. This was established, for example, by Mr. C. V. Barker* in his experiments on "the formation of regular growths of crystals of one substance upon those of another." Parallel growths of sodium nitrate crystals on calcite surfaces are shown on Plate XX, Figs. 63, 64 and 65, of Sir George Beilby's book entitled, "Aggregation and Flow of Solids." It seems probable, therefore, that in the present case the oxide first formed is magnetite Fe_3O_4, which has a cubic symmetry like alpha iron. The surface crystals, however, which were removed with a penknife, were not attracted by a magnet, indicating that they had been further oxidised, probably to Fe_2O_3, without change of form. It is well known that hematite crystallises in the hexagonal system, but this oxide has been obtained in a form pseudomorphous with magnetite by heating the latter in a blowpipe flame for several hours. The crystals oxidised without change of form.† A type of structure somewhat similar to that described above was obtained by Osmond and Cartaud.‡ They heated to redness a crystal of iron (which had one of the cube faces polished) in a nickel crucible packed with calcined magnesia and covered with cast-iron shavings. To use their own words in describing the results of this experiment: "The polished face oxidised naturally and displayed square figures strongly resembling corrosion figures. . . . It seems that the oxidation has been regulated by the structure of the metal."

As has been already stated, the characteristic structures of oxide described in the present paper are only produced under the combined influence of the gases evolved from both copper and iron. The mere oxidation of the iron which always takes place to some extent when it is heated by itself in an evacuated silica tube, does not produce these structures at all. What has to be explained, if possible, is the oxidation of the iron in a particular way under the combined influence of the gases simultaneously evolved both from iron and copper. The effects are only produced by copper containing the gases normally present in the metal. If the copper be previously heated *in vacuo* several times until no gases are evolved and be then heated with iron in an evacuated tube, it remains quite bright, while the iron oxidises slightly without the production of the characteristic facets of oxide. Both the composition and volume of the gases contained in copper vary within fairly wide limits. Several samples of the metal, however, produced similar effects on the iron. The action, therefore, clearly takes place with gases whose composition varies to some extent. The gases collected when one specimen of the copper used in the authors' experiments was melted *in vacuo*, gave the following results on analysis:—

	Per Cent.
Hydrogen sulphide and sulphur dioxide	61·2
Carbon dioxide	34·9
Oxygen	1·1
Residual gas (nitrogen)	2·8

It is to be noted that this mixture contains only just over 1 per cent. of free oxygen, but that there is a considerable amount of oxygen present combined with carbon and sulphur. Less information exists with regard to the gases present in iron. The majority of gas analyses have been carried out on steels, and in these cases the gases appear to consist of mixtures of the oxides of carbon together with hydrogen and nitrogen. It is impossible to predict what would be the equilibrium in a system composed of the metals, copper and iron, at temperatures of from 900 deg. to 1,000 deg. C., which was evolving a mixture of the above types. Broadly speaking, however, it appears that under these conditions the atmosphere produced is decidedly oxidising both as regards the copper and the iron. In their experiments the authors have noticed the deposition of free sulphur in the cooler parts of the quartz tube. This points to the decomposition of the sulphur dioxide always present in the copper, and the result would be the production of free oxygen. Another source of this gas is possibly the decomposition of some cuprous oxide. The fact that the production of the characteristic facets of oxide requires a period of considerable duration for its completion is due, no doubt, to the gradual liberation of the gases over this period. Those contained in and evolved from the copper must be held to be the chief cause of the characteristic structures of iron oxide produced, but the influence of their possible interaction with the gases evolved on heating the iron itself must not be lost sight of.

Summary.—Samples of Armco, electrolytic and Swedish iron were heated from below 900 deg. to above 1,000 deg. C., in an evacuated quartz tube and oxidised slightly without producing any characteristic crystallographic features on the surface of the metal. If, however, a specimen of copper be introduced as well containing the gases which are ordinarily present in the metal, a reaction sets in resulting in the gradual production and development of characteristic facets on the surface of the iron. These are due to the production of what is probably the oxide Fe_3O_4 which subsequently passes to Fe_2O_3 without change of form. The oxide of iron originally produced is isomorphous with alpha iron, and the orientation of the oxide produced on any given crystal of iron is determined by the orientation of the alpha iron itself. It is, in other words, "a parallel growth" of the magnetic iron oxide. Once produced the form of the oxide is uninfluenced by heating the specimen to a temperature at which gamma iron is formed. A somewhat similar phenomenon was observed sixteen years ago by Osmond and Cartaud. The principal agent in the production of the characteristic facets of oxide is the mixture of gases evolved by the copper on heating.

FIG. 1. COPPER HEATED IN VACUO IN THE PRESENCE OF ARMCO IRON. × 300.

FIG. 2. ARMCO IRON HEATED IN VACUO IN THE PRESENCE OF COPPER. × 300.

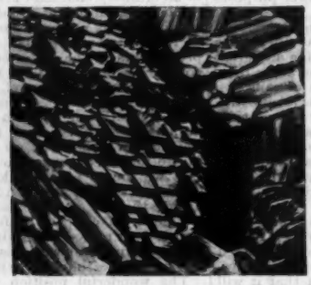


FIG. 3. ARMCO IRON AFTER MORE PROLONGED HEATING. × 600.

FIG. 4. TWO ADJACENT GRAINS OF ELECTROLYTIC IRON AFTER HEATING. × 300.

FIG. 5. × 600.

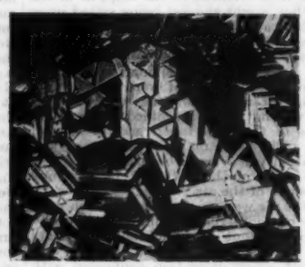


FIG. 6. × 600.

ARMCO IRON AFTER HEATING IN VACUO FOR TWO HOURS, SHOWING RECTANGULAR AND TRIANGULAR FIGURES.

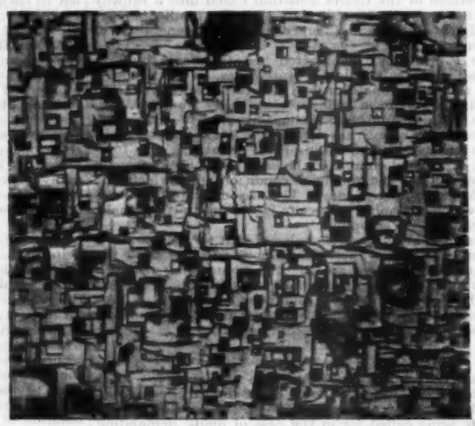


FIG. 7. CRYSTAL OF ELECTROLYTIC IRON SHOWING MINUTE SQUARE AND RECTANGULAR FIGURES. × 600.

* Journal of the Chemical Society, 1906, vol. lxxxix, page 1120.

† Friedel, Bull. Soc. Franc. Min., 1894, vol. xvii, page 450.

‡ Journal of the Iron and Steel Institute, 1906, No. III, page 481.

DOMESTIC LABOUR-SAVING APPLIANCES.—Awards have now been made in the competition for women, arranged by the Women's Engineering Society, for domestic labour-saving devices. The competition was divided into three sections: (*a*) engineering and mechanical devices; (*b*) structural improvements; and (*c*) miscellaneous. The awards are as follows: Section A—Miss Ashberry, for dish washing machine. Section B—No award has been made. Section C—Miss Ramage, for "Ideal" oven. Two certificates of merit have also been awarded in Section C, one to Mrs. Lockyer for the "Hotlock and Coldlock," and one to Miss Long for "Forty plates in one." The Women's Engineering Society hope at a future date to hold a second competition.

MINERS' SAFETY LAMPS OF BRITISH MANUFACTURE.—Under Section 33 of the Coal Mines Act no safety lamp may be used in any pit where the use of such lamps is obligatory unless it is of a type approved by the Home Secretary (now the Board of Trade). Before the war almost all the glasses for flame safety lamps were imported from Germany and Austria. In 1914, the then Home Secretary urged certain British glass manufacturers to undertake the difficult and expensive process of manufacturing glasses of the necessary quality in sufficient quantities to satisfy the British demand. He pledged himself, if they were successful in doing this, to refuse, during a period of three years from the termination of the war, to approve any lamps containing glasses manufactured in Germany or Austria. The manufacturers have carried out their part of the bargain. But the Board of Trade are advised that it is doubtful whether a refusal to approve a lamp merely on account of the country of origin of its glass is *intra vires* Section 33 of the Coal Mines Act. A Bill has therefore been introduced in Parliament to place beyond question the legality of the action of the Board of Trade in fulfilling the Home Secretary's pledge.